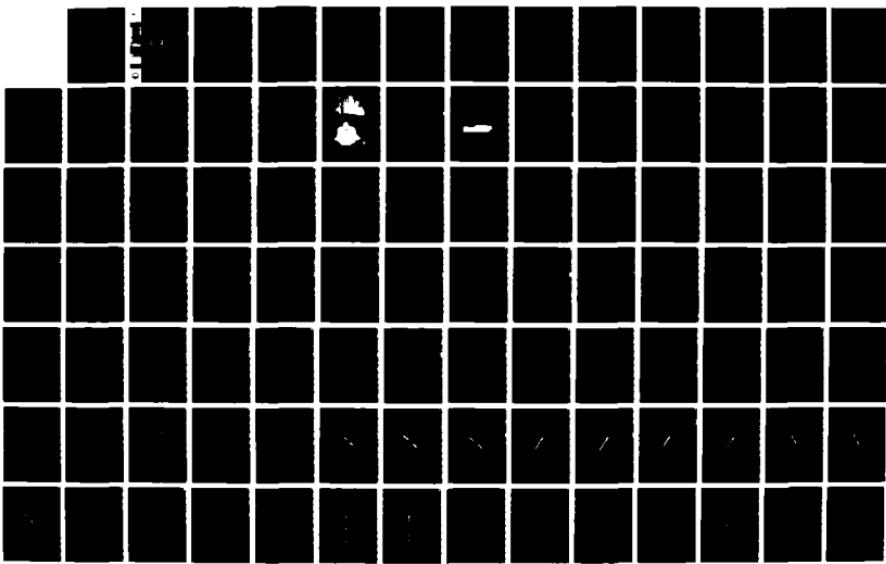
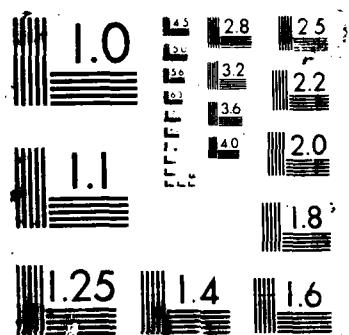


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# TIDAL ELEVATIONS AND CURRENTS AT PONCE DE LEON INLET, FLORIDA

by

J. Michael Hemsley, Michael J. Briggs

Coastal Engineering Research Center

DEPARTMENT OF THE ARMY  
Waterways Experiment Station, Corps of Engineers  
PO Box 631, Vicksburg, Mississippi 39180-0631

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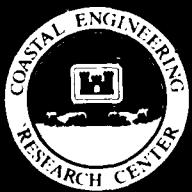
May 1988  
Final Report

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17 COSATI CODES FIELD    GROUP    SUB-GROUP	18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Currents Tides		
19 ABSTRACT (Continue on reverse if necessary and identify by block number) Tidal elevation and current data were measured and analyzed at Ponce de Leon Inlet for use in calibrating model studies that will evaluate alternative improvements to the weir jetty system.			
Data were successfully obtained from four of six Sea Data TDR-2 pressure sensors and 14 Endeco 174 current meters during the period September to November 1983. Quality of the data was excellent with very few spikes or missing points. Hardware-related problems occurred on the TDR for Gage T7 due to flooding. Two of the Endeco gages at sta 2B lost their impellors due to high sediment and current flows and/or fishing activity in the inlet throat.			
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19. ABSTRACT (Continued).

Tidal harmonic analysis of 56 days of National Ocean Survey (NOS) tide data, using Coastal Engineering Research Center's software, verified the accuracy of the program and provided a reference for tidal elevation and current harmonic analysis results. The root mean square (rms) error was 0.11 ft. Constituent amplitudes and local epochs for 10 constituents agreed quite well with NOS's data for the full calendar year of 1974 from Daytona Beach Pier using 37 constituents.

Pressure and surface elevation time series and harmonic analysis plots are presented for tidal elevation data collected in Ranges 3 through 6. Mean water depths ranged from 5.46 to 23.00 ft. The maximum tidal range was 3.5 ft at Range 4. The harmonic analysis results were very good for Ranges 3 and 4 with rms errors of 0.07 and 0.08 ft, respectively. For Ranges 5 and 6, the rms errors were higher at 0.35 and 0.28, respectively, but still very good.

For the tidal current data, current roses, vector (stick) plots, current velocity magnitude time-series, current direction time-series, and harmonic analysis plots are presented. The maximum velocity recorded was 3.0 ft/sec at Range 3 for flood flow and 4.6 ft/sec at Range 2 for ebb flow. In general, these values are consistent with those reported earlier.

Temperature data were remarkably consistent between TDR and Endeco gages, showing the same general trends. The range of temperatures was approximately 22.5° to 28.5°C.

Conductivity data were recorded by the Endeco current meters and ranged from approximately 30 to 55 mmho/cm.

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## PREFACE

Authority for the US Army Engineer Waterways Experiment Station (WES) to conduct this study from September through November 1983 was contained in Intra-Army Order for Reimbursable Services CW-83-0148 from the US Army Engineer District, Jacksonville, Jacksonville, Fla.

The study was conducted by personnel of the Coastal Engineering Research Center (CERC), WES, under the general direction of Dr. James R. Houston, Chief, and Mr. Charles C. Calhoun Jr, Assistant Chief, CERC; Dr. Frederick E. Camfield, Acting Chief, and Dr. William L. Wood and Mr. Thomas R. Richardson, successive Chiefs, Engineering Development Division; and Dr. Dennis R. Smith, Chief, Prototype Measurement and Analysis Branch. The field data collection effort was planned by Mr. J. Michael Hemsley, Research Hydraulic Engineer, Mr. Thomas H. Flor, Physical Scientist, Mr. Terry L. Miloser, Equipment Specialist, and Messrs. Michael D. Dickey and Ralph E. Ankeny, Civil Engineering Technicians. Data analysis was planned and conducted by Mr. Michael J. Briggs, Hydraulic Engineer. Some of the software development was provided by Dr. Michael E. Andrew, Statistician, and Mr. James Rosati, Hydraulic Engineer. Mr. Toby Wilson, Civil Engineer Technician, performed some of the data reduction. This report was prepared by Messrs. Hemsley and Briggs. The Jacksonville District Technical Monitor for this effort was Mr. Earl Howard.

Commander and Director of WES during the conduct of this study and the preparation and publication of this report was COL Dwayne G. Lee, CE.

Technical Director was Dr. Robert W. Whalin.

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## CONVERSION FACTORS, NON-SI TO SI (METRIC)

### UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
Fahrenheit (degrees)	5/9*	Celsius degrees or Kelvins
feet	0.3048	metres
inches	2.54	centimetres
miles (US statute)	1.609347	kilometres
pounds per square inch gage	6.894757	kilopascals
tons (2,000 pounds, mass)	907.1847	kilograms

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\* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula:  $C = (5/9)(F - 32)$ . To obtain Kelvin (K) readings, use:  $K = (5/9)(F - 32) + 273.15$ .

TIDAL ELEVATIONS AND CURRENTS AT  
PONCE DE LEON INLET, FLORIDA

PART I: INTRODUCTION

Background

1. Ponce de Leon Inlet is in Volusia County on the east coast of Florida about 65 miles\* south of St. Augustine Harbor and 57 miles north of Canaveral Harbor (Figure 1). The inlet is a natural waterway stabilized by jetties which connect the Atlantic Ocean with the Halifax and Indian rivers, both of which join the Intracoastal Waterway. The current configuration of the stabilized inlet includes a rubble-mound north jetty with a weir section, an impoundment basin adjacent to the weir section, and a short rubble-mound south jetty (US Army Engineer District (USAED), Jacksonville, 1983).

2. The weir section of the north jetty was constructed during the period 1968 through 1972 when no criteria existed for the design of weir jetties. Design of the project, therefore, included monitoring the behavior of the inlet following construction. To facilitate future adjustments, the weir was constructed with king piles and concrete panels (USAED, Jacksonville, 1983).

3. Monitoring efforts at the inlet, performed after construction of the jetties, revealed a general pattern of erosion to the north of the inlet and accretion to the south (Purpura et al. 1974, Purpura 1977). Eventually, sand filled the area south of the south jetty and then began bypassing this area. A large accumulation of sand has formed north of the south jetty, forcing the channel northward through the impoundment basin. Figure 2 shows the development of the south shoreline. Migration of the channel and the lack of sand passing over the weir have rendered the impoundment basin ineffective.

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\* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

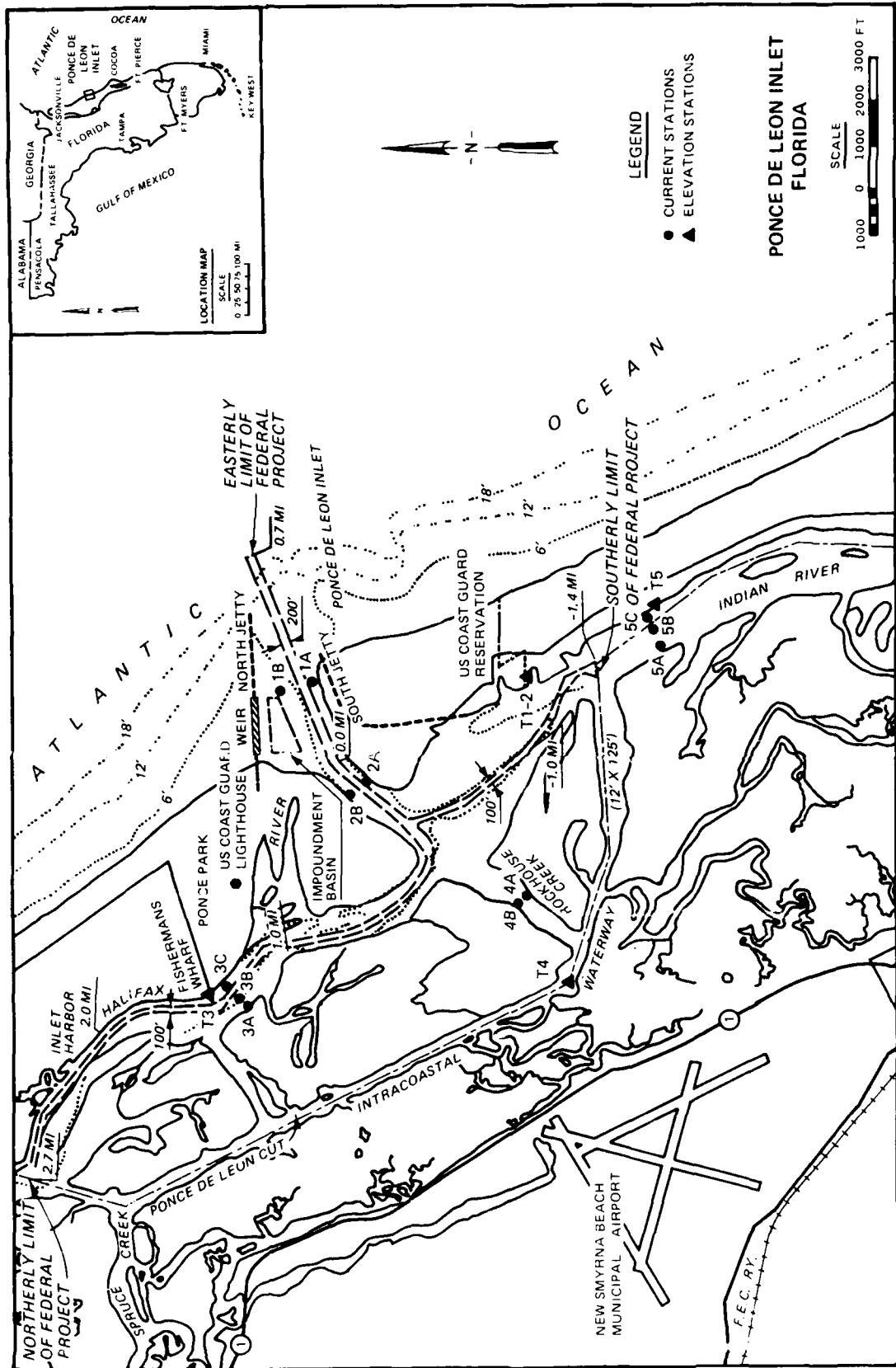


Figure 1. Ponce de Leon Inlet, Florida

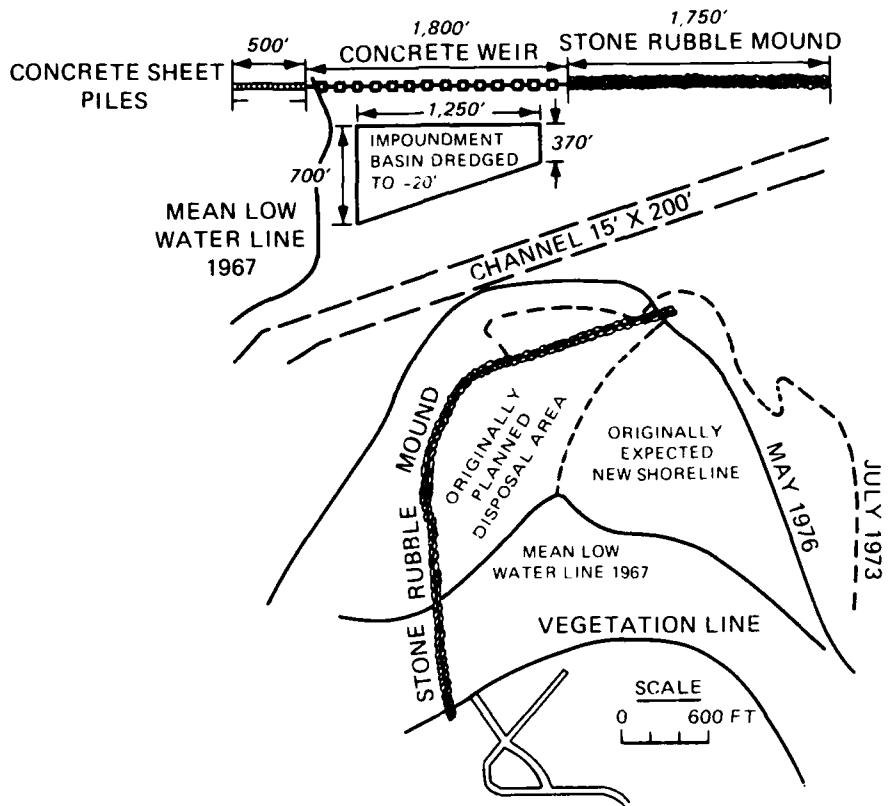


Figure 2. Growth of the south beach  
(from USAED, Jacksonville, 1967)

#### Purpose

4. Jacksonville District, as a result of the failure of the weir-jetty system to perform as designed, initiated an investigation "to examine the performance of the Ponce de Leon Inlet Navigation Project and, based on the results of this examination, develop the most effective plan for future maintenance of the Navigation Project" (USAED, Jacksonville, 1983). The intent was to adjust the weir in a manner that would reduce waves and currents in the channel caused by overtopping of the weir and cause the channel to move away from the north jetty. The weir would be closed by inserting concrete panels between the existing king piles and then covering these panels with armor stone (Figure 3). Removal of the buildup north of the south jetty and renourishment of the north beach would follow the weir closure.

5. During the stabilization of the beach-inlet system, a model study is planned at the US Army Engineer Waterways Experiment Station (WES) to evaluate

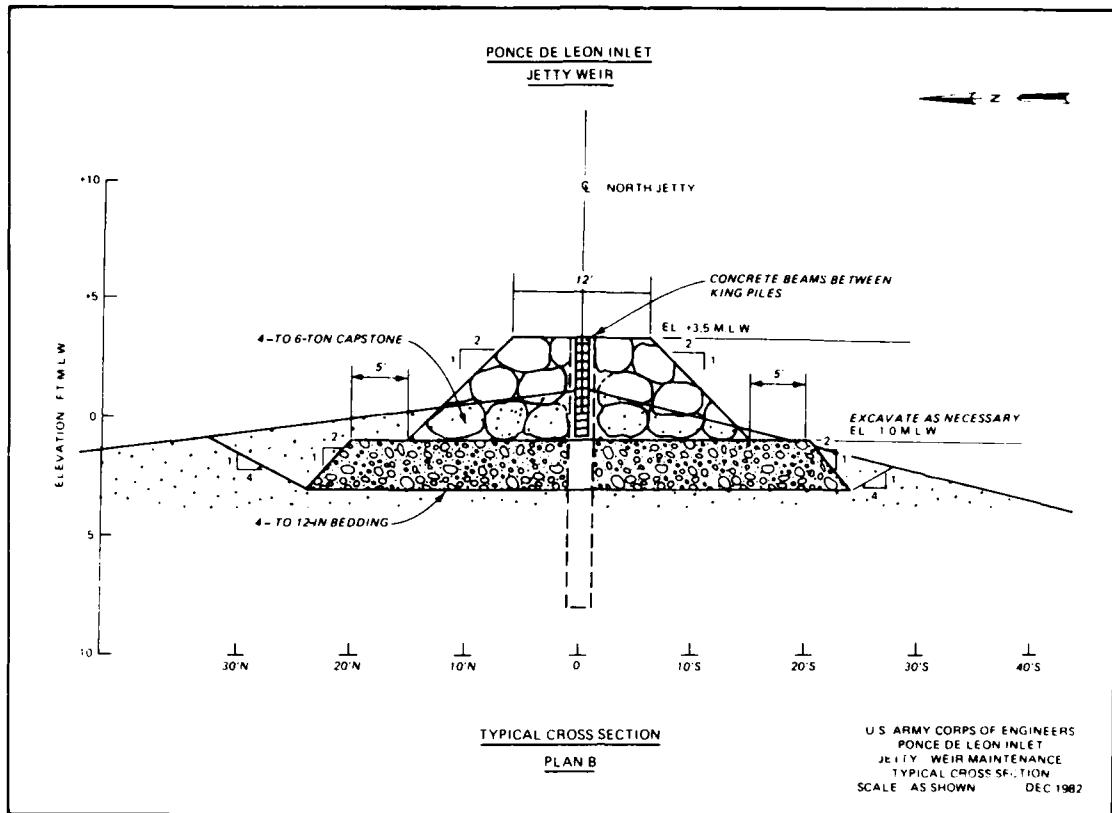


Figure 3. Closure of Weir

alternative improvements to the weir-jetty system. Figure 4 identifies the proposed model layout for this study. To provide baseline data for the model study, tidal elevations and currents were measured at the inlet and are reported herein.

#### Previous Studies

6. There have been a number of studies performed at Ponce de Leon Inlet since completion of jetty construction during 1972. The original design was developed prior to the publication of the Shore Protection Manual and other guidelines for weir-jetty design. Consequently, Jacksonville District supported investigations by the University of Florida to monitor the performance of the jetty system. These studies have been reported by Purpura et al. (1974) and Purpura (1977), and summarized by Jones and Mehta (1978). Each of these studies has produced the same general conclusion: close the weir, stabilize the inlet, and make improvements as needed to the jetty system.

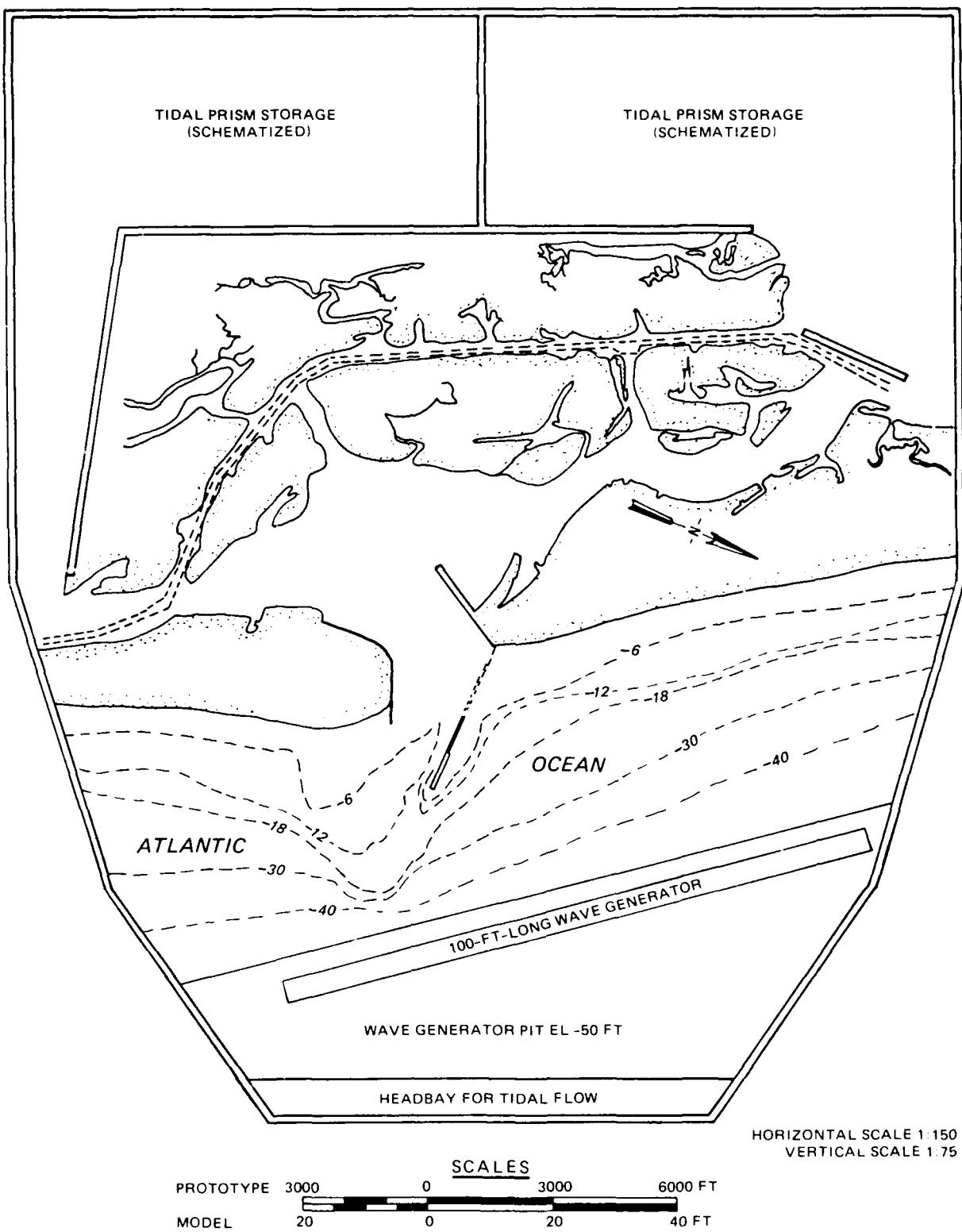


Figure 4. Proposed model layout for Ponce de Leon Inlet

Considerable data were collected and reported through these studies. A brief summary of these data, which includes the position of the navigation channel, tidal elevations and currents, and other hydraulic parameters, is contained in this report.

7. While the jetties have provided a deep navigation channel, Figure 5

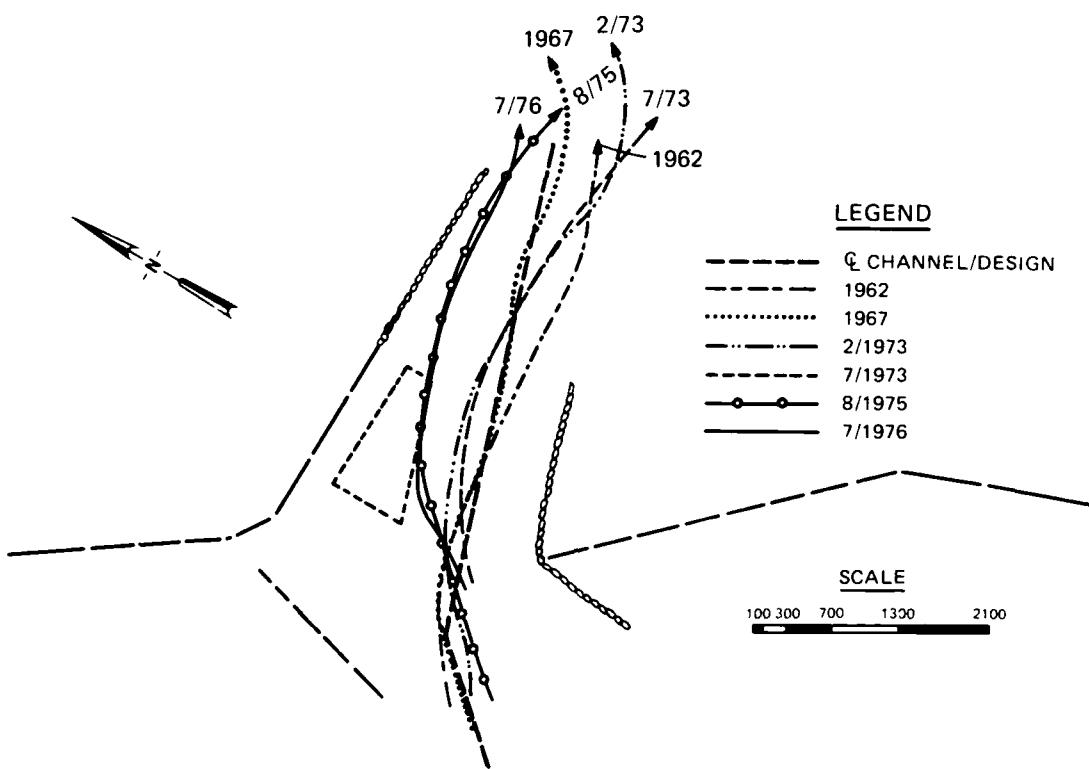


Figure 5. Historical movement center line of channel, Ponce de Leon Inlet  
(after Jones and Mehta 1978)

shows how the channel has migrated northward alongside the north jetty. Consequently, stability of the jetty toe could be endangered by scour from tidal currents. In addition, boaters are faced with dangerous navigation conditions when strong winds blow from the south.

8. Tidal elevation data for the Ponce de Leon Inlet area are available from several sources: the National Ocean Survey (NOS) which operated tide gages on the pier at Daytona Beach, and the US Coast Guard (USCG) Station which is located inside the inlet. Table 1 lists tidal ranges from the NOS tide tables. Figure 6 shows the location of the two NOS gages as well as four other tide recorders used in the Corps sponsored studies during 1974

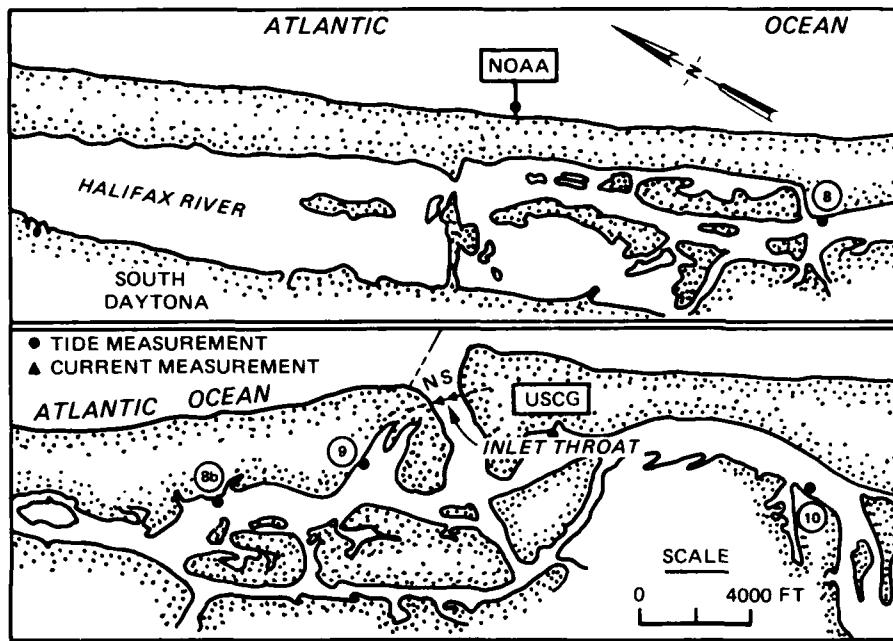


Figure 6. Tide and current measurement locations, previous studies (NOAA = National Oceanic and Atmospheric Administration) (after Jones and Mehta 1978)

(locations 8, 9, and 10) and 1976 (all six locations). Tidal elevations measured and reported by Purpura (1977) are shown on Figure 7.

9. During the field work conducted in 1976, tidal current measurements were taken at stations in the inlet throat shown on Figure 6. Figure 7 also contains these current data. Purpura (1977) said, "The highest measured point velocity for ebb flow was 4.5 ft/sec at 1.65 ft below the surface." This study indicated that flood flows were stronger than ebb flows.

10. The pattern of tidal currents has also been studied at the inlet by using dye and drogue studies (Purpura et al. 1974). Dye patterns indicated a strong flood current against the north edge of the channel and that flow over the weir during flood flow followed the northern boundary of the channel. During ebb flow, stronger velocities were found along the south bank. A strong southerly current along the beach north of and across the weir was also revealed. This current appears to be independent of wave direction.

11. In 1976, both drogues and dye were used to trace current patterns in the inlet throat. As shown in Figure 8, neither the flood nor the ebb flow follows the design channel. Both flows are strong through the deposition

basin, hugging the north jetty, with considerable flow passing across and/or through the weir.

12. Studies performed at Ponce de Leon Inlet include also a one-dimensional numerical model (Purpura 1977), a wave refraction analysis (Purpura et al. 1974, Purpura 1977), tidal prism analysis (Jones and Mehta 1978), and considerable topographic and bathymetric data review. The reader is referred to the references for additional information.

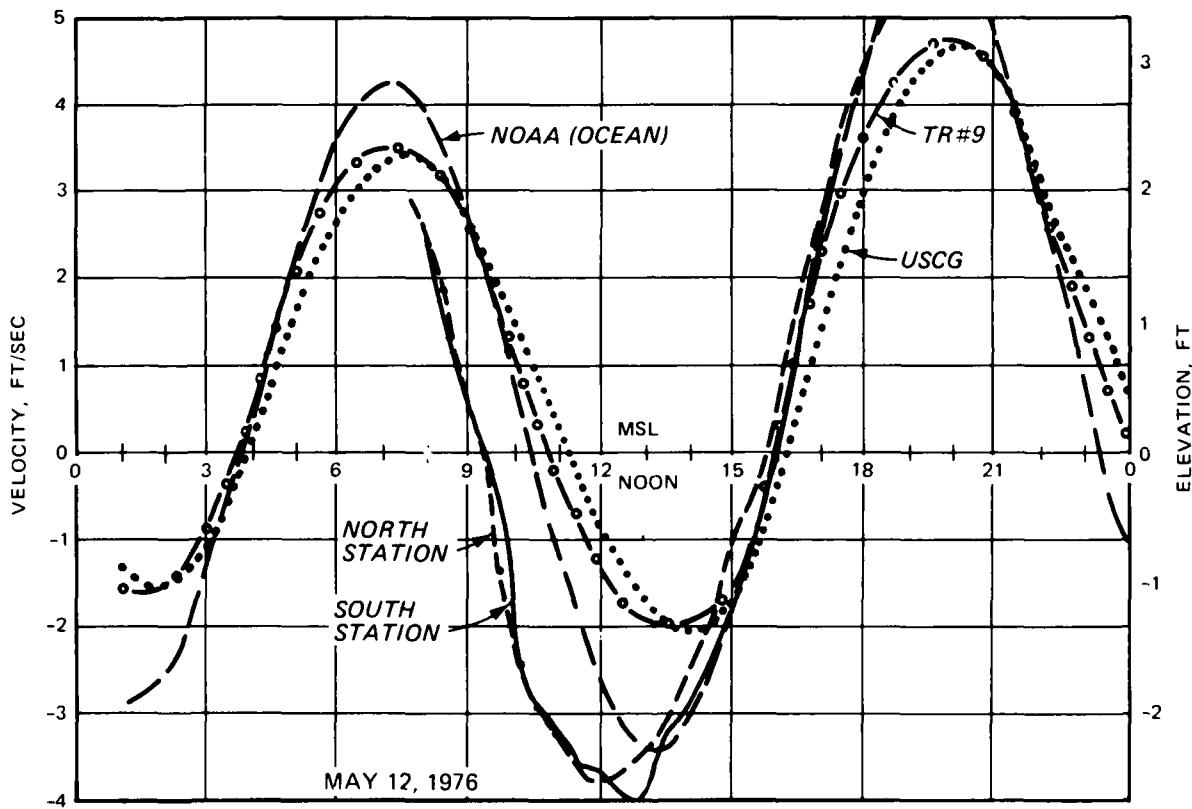


Figure 7. Tidal elevations and currents (msl = mean sea level)  
(NOAA = National Oceanic and Atmospheric Administration)  
(after Purpura 1977)

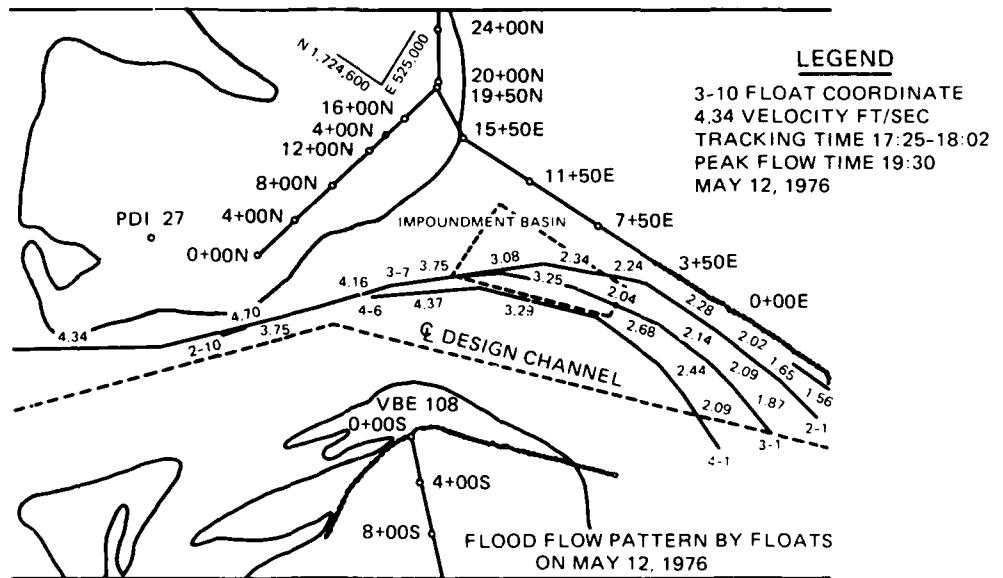
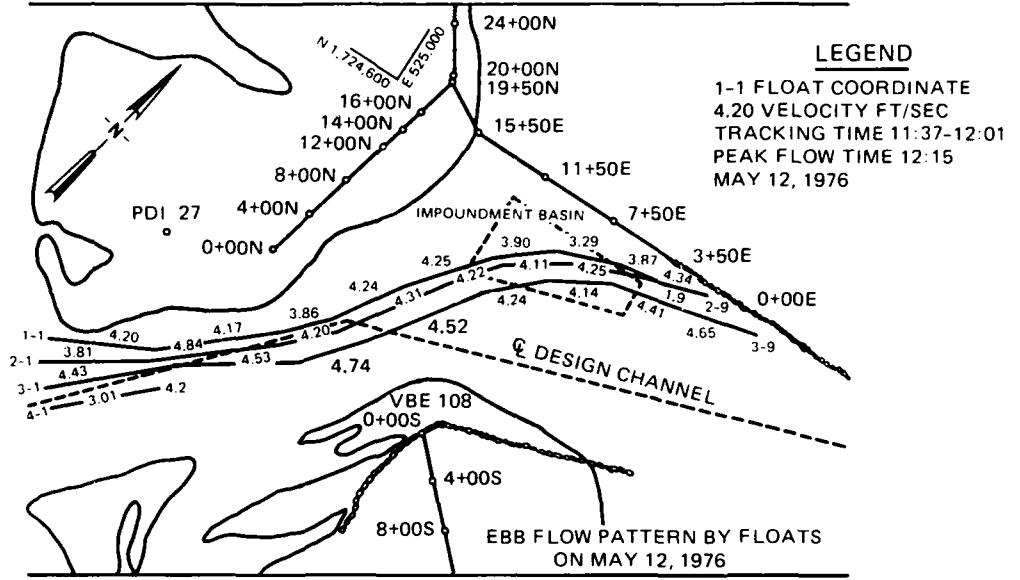


Figure 8. Current patterns (after Purpura 1977)

## PART II: FIELD DATA COLLECTION

### Planning

13. The decision to acquire baseline tidal elevation and current data was made late in FY 1983. This allowed limited time to plan and obtain 1 month's data before winter storms set in. The plan involved the deployment of six Sea Data TDR-2 pressure sensors (Figure 9) and eighteen Endeco 174 current meters (Figure 10), as well as acquiring tide data from the existing NOS gage at Daytona Beach. The data will be used in the physical model study (Figure 4), so instruments were deployed primarily within the model boundaries except for two tide gages located some distance to the north and south to calibrate the tidal prism storage.

14. After meetings at WES and a site visit, the final instrument stations were determined. Initially, a tide gage was planned for the inlet mouth, but the lack of any fixed structure on which to mount the instrumentation precluded installation. Instead, a gage was installed at the USCG dock inside the inlet. Figure 11 shows the measurement stations within the model boundaries. Two additional stations were included: one approximately 6.4 miles north of the inlet, just north of the Bascule Bridge into Daytona Beach, and the other 4.4 miles south of the inlet at the Smyrna Yacht Club.

15. Installation was scheduled for the week of 25 September 1983. It was estimated that 1 week would be necessary to assemble and install all the instrumentation. The instruments would remain in the water through at least one lunar cycle.

16. During the reconnaissance trip, pile dimensions were recorded, arrangements were made with the Coast Guard to use their facility as a staging area, and property owners were contacted concerning the installation of tide gages on their property. Mounts which could be installed by divers for the TDR-2's were fabricated. Meanwhile, discussions were conducted with Endeco, Inc., to determine the best mooring system for current meters in an inlet with swift tidal currents. Figure 12 illustrates the mooring system developed. Two current meters would be installed on each mooring at measurement sta 1A and 1B, 2A and 2B, and 4A and 4B. Only one instrument would be placed at the remaining stations that were located in shallower water. Table 2 summarizes the instrument locations.

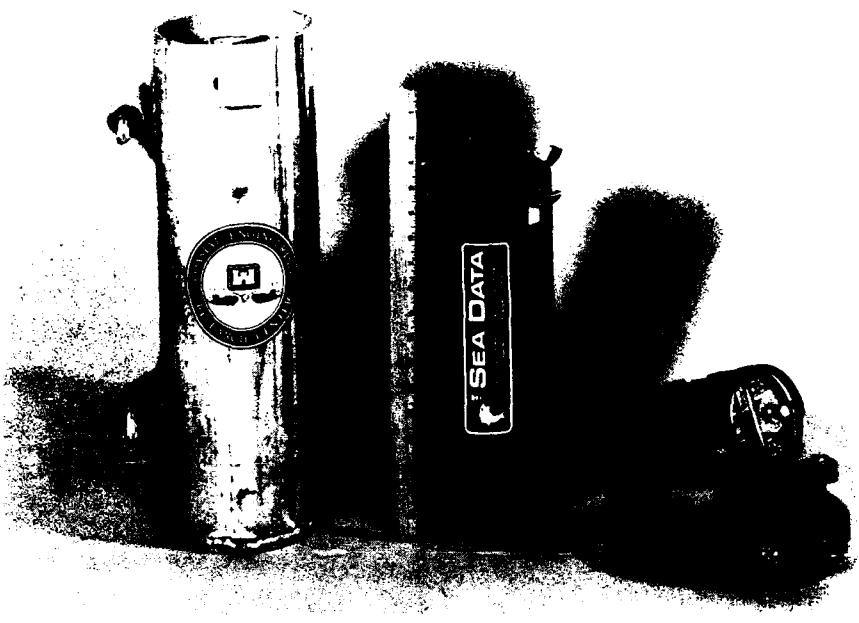


Figure 9. TDR-2 pressure sensor

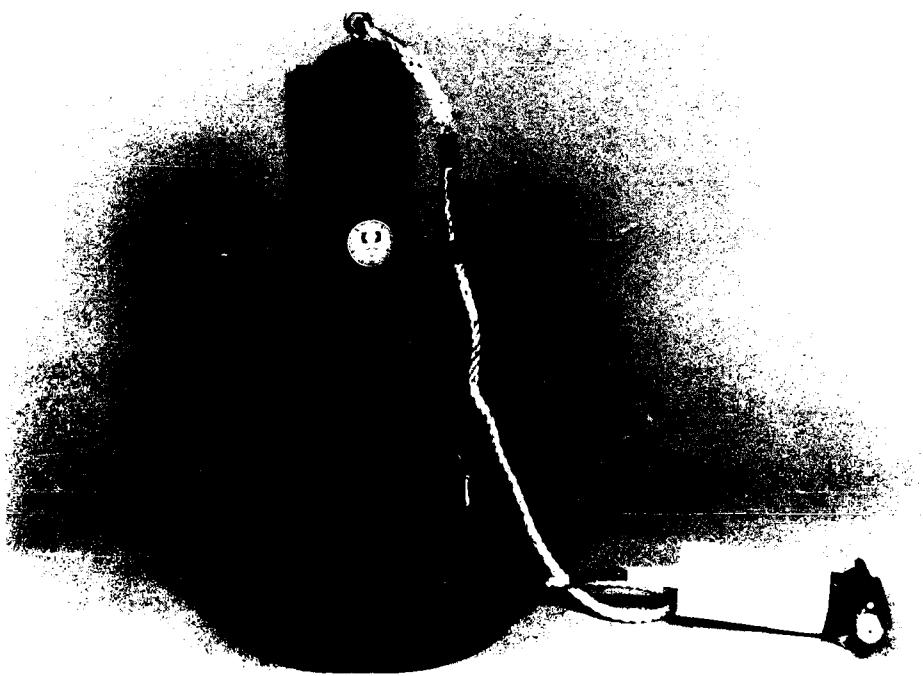


Figure 10. Endeco 174 current meter

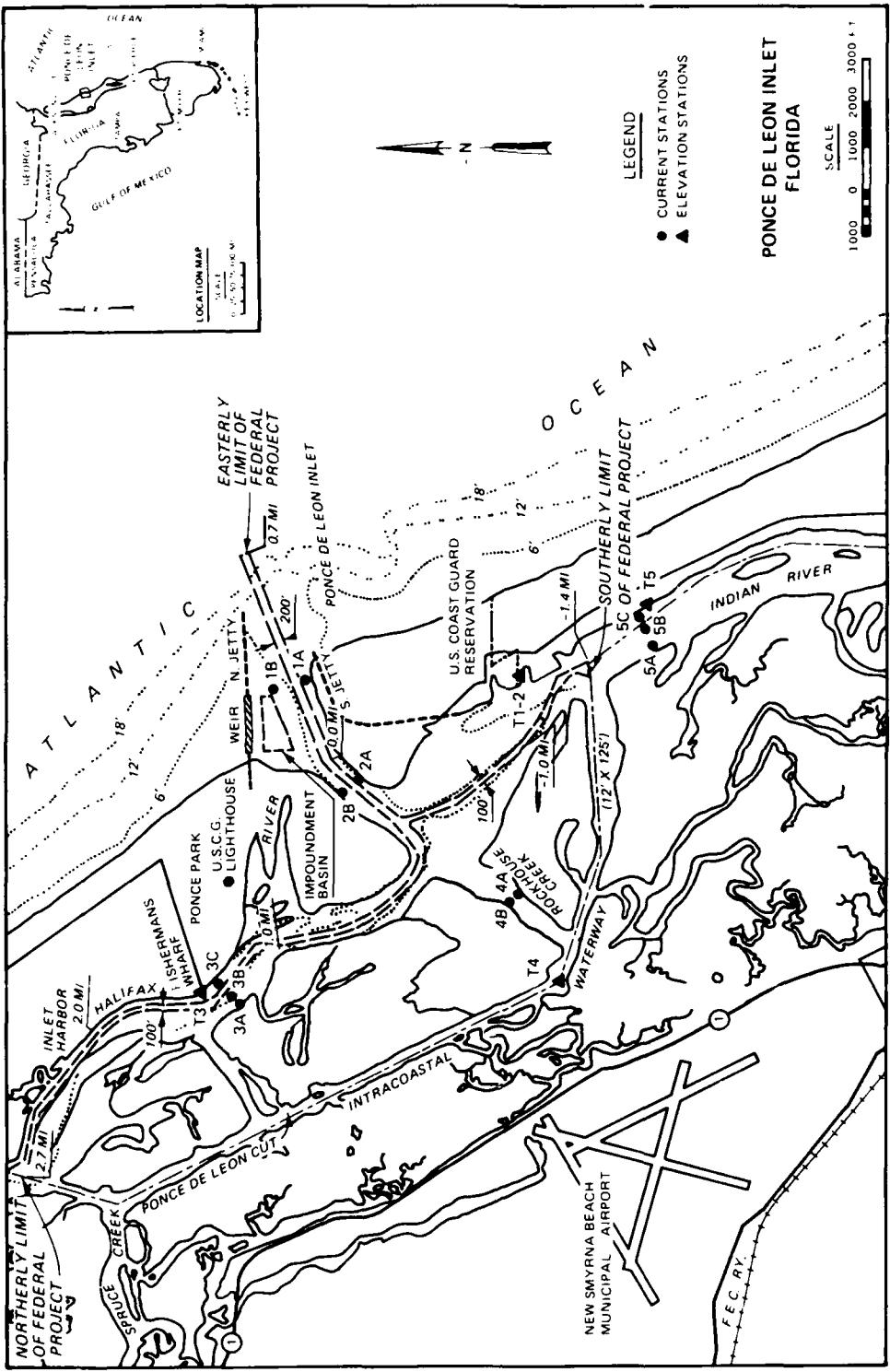


Figure 11. Measurement stations

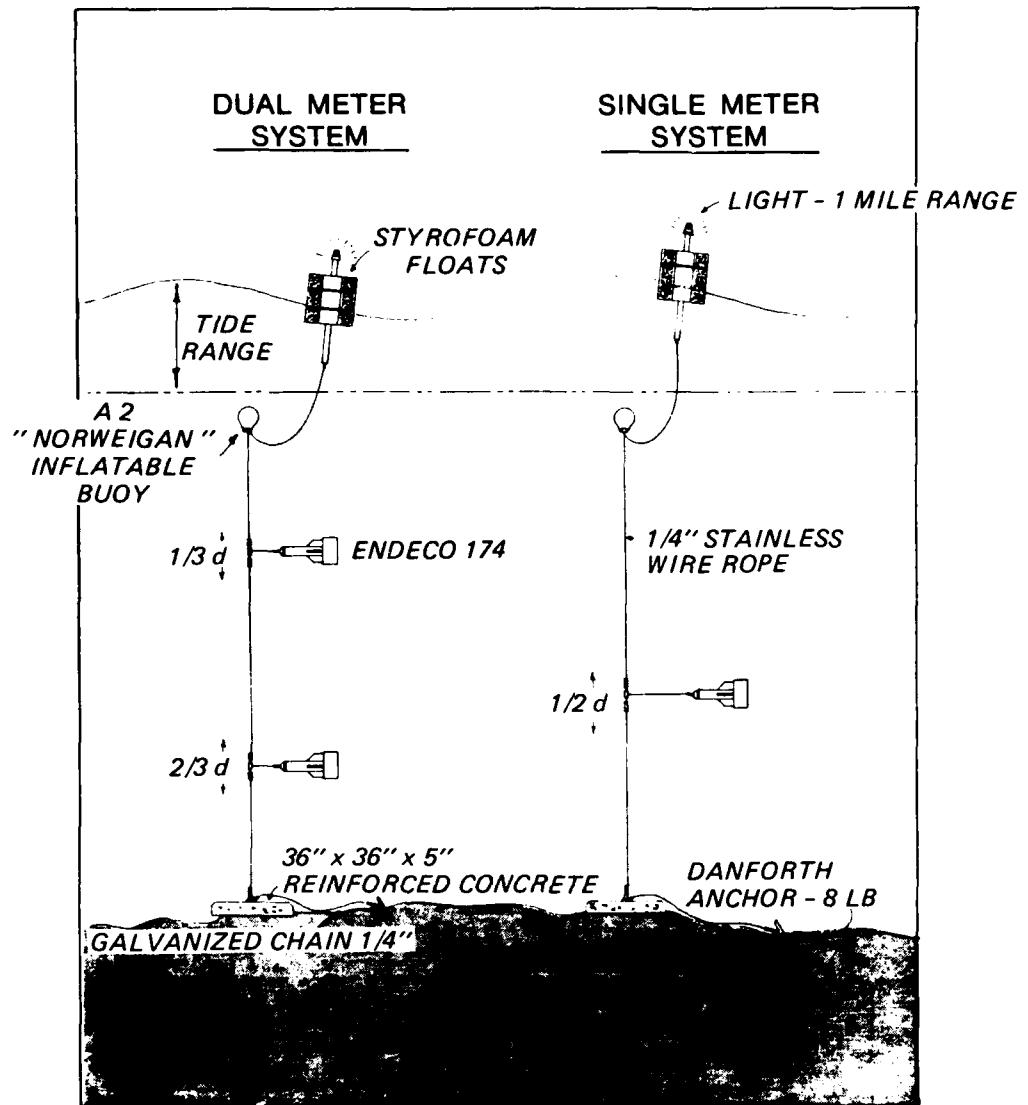


Figure 12. Current meter mooring system

#### Data Collection

17. The instrumentation was installed between 25 September and 1 October 1983. The operation was conducted with only one persistent problem: continuous rough conditions in the mouth of the inlet as a result of the overtopping of the north jetty precluded installation of the meters on Range 1 (sta 1A and 1B). Thus, an Endeco 110 current meter was brought to the site from WES and deployed from a small boat. Two personnel remained onsite to maintain the surface floats and to monitor the condition of the moorings.

18. All instrumentation remained in place until the week of 7 November 1983. The instruments, the mounts, and the bulk of the mooring systems were then removed. Since current measurements had been made with the Endeco 110's for limited periods on 2 days, additional current data were required for the inlet mouth.

19. By monitoring weather charts and the real-time wave data collected by the University of Florida for WES's Hurricane Surge Prototype Data Collection Program, it was determined that wave conditions inside the inlet would be acceptable for a few days around 26 January 1984. Thus, on 27 January 1984 the additional current data were collected. Readings were taken once each hour at each station on Ranges 1 and 2 (Figure 12) at two depths, approximately one-third and two-thirds the water depth. Table 3 shows the data collected. Eleven of the desired thirteen hours of measurements were taken. Conditions in the inlet mouth necessitated the use of a sizeable vessel with twin engines in order to hold position during the measurements. The vessel used was limited by USCG regulations to a total of 12 working hours per day, as were all other suitable and available commercial vessels.

#### Data Recovery

20. Table 4 shows the data recovered during the collection period. Data recovery was very good. Four tide gages collected complete data sets, and at sta 1-2, a portion of the data was collected while the tide gage at sta 7 suffered a seal failure soon after installation, and no data were collected.

21. The percent recovery for the Endeco 174 current meters was excellent. All meters collected complete data on current direction, temperature, and conductivity. Twelve of the meters collected data on current velocity as well, while the remaining two meters at sta 2B collected nearly 2 weeks of velocity data. Suspended sediment and swift water velocities in the inlet throat combined to cause the failure of impeller bearings on the meters at sta 2B. (These failures might have been exacerbated by fishermen tangling their lines in the impellers, but that is mostly conjecture.)

22. These data losses, while unfortunate, will not seriously impact the operation of the model since sufficient data were collected to allow proper calibration.

### PART III: DATA ANALYSIS

#### Data Presentation Formats

23. Tabular listings and plots are the two forms of data presentation used to document the data collection effort. Tabular listings were generated for model verification. Figure 13 is an example of a TDR listing for Gage T4 (PI152). This listing gives the date, time, pressure, and depth data at 5-min intervals. Figure 14 is the corresponding TDR listing for temperature data in both degrees Celsius and Fahrenheit. Figure 15 is an example of an hourly listing for the Endeco 174 gages of date, time, current speed and direction, temperature, and conductivity for Gage 2AB. Interval listings of 10 and 2 min were also prepared for the current meters for use in model verification. Due to the voluminous nature of these listings, none have been included in this report, but they are available from the authors upon request.

24. The following three types of plots were generated to display the data: time series plots, current vector "rose" diagrams, and harmonic analysis plots. Time-series plots are x-y plots that show the variation of a parameter such as surface elevation versus time in days. A current rose is a graphical method of illustrating current magnitude and direction for a set of data points. The rose consists of seven concentric rings, spaced every 0.5 ft/sec, with the origin at zero speed. Points are plotted radially about the origin, the magnitude given by the distance from the origin and the direction measured from true north at the top of the diagram. The current flows in a direction emanating from the origin toward the plotted point. Finally, harmonic analysis plots consist of two curves overlain on one graph; the first curve shows the measured data, and the second curve illustrates the calculated values. A second graph shows the corresponding tidal harmonic analysis residuals or differences between the first two curves.

25. To facilitate comparison among the different gages and locations, an effort was made to standardize x- and y-axis scales with the greatest resolution. Table 5 is a summary of plot formats listings the x- and y-axis ranges and units of measure for each parameter plotted. The instrument used (i.e. source) to measure these data is also given. For time-series plots, the beginning x-axis value is dated 27 September 1983 with 7-day increments between annotations. The one exception is the NOAA tidal height data. Due to

Figure 13. Example TDR pressure (in pounds per square inch gage (PSIG)) and depth listing for Gage T4 (PI152)

TABLE 1  
GAGE TEMPERATURES - SHIFT TO FGA

PAGE 1

LATE	TIME	TEMP. C. & F.																	
8-27-83	16:17	77.78	16:20	77.47	16:23	77.17	16:25	76.84	16:28	76.50	16:30	76.18	16:33	75.85	16:35	75.56	16:38	75.34	16:40
8-27-83	16:43	77.15	16:46	77.01	16:49	76.87	16:52	76.73	16:55	76.61	16:58	76.49	17:01	76.36	17:04	76.25	17:07	76.15	17:10
8-27-83	20:03	77.53	20:07	77.41	20:10	77.35	20:13	77.31	20:16	77.28	20:19	77.24	20:22	77.20	20:25	77.15	20:28	77.10	20:30
8-27-83	20:41	77.04	20:44	76.97	20:47	76.91	20:50	76.84	20:53	76.78	20:56	76.71	21:00	76.63	21:03	76.54	21:06	76.49	21:09
8-27-83	21:18	76.56	21:21	76.50	21:24	76.44	21:27	76.38	21:30	76.32	21:33	76.26	21:36	76.20	21:39	76.14	21:42	76.08	21:45
8-27-83	21:46	76.14	21:49	76.09	21:52	76.04	21:55	75.99	21:58	75.93	22:01	75.87	22:04	75.81	22:07	75.77	22:10	75.72	22:13
8-27-83	22:11	75.74	22:14	75.70	22:17	75.65	22:20	75.60	22:23	75.55	22:26	75.50	22:29	75.45	22:32	75.40	22:35	75.35	22:38
8-27-83	22:46	76.07	22:49	76.03	22:52	75.98	22:55	75.93	22:58	75.88	23:01	75.83	23:04	75.78	23:07	75.73	23:10	75.68	23:13
8-27-83	23:01	76.46	23:04	76.42	23:07	76.37	23:10	76.32	23:13	76.27	23:16	76.22	23:19	76.17	23:22	76.12	23:25	76.07	23:28
8-27-83	23:41	77.04	23:44	76.98	23:47	76.92	23:50	76.86	23:53	76.80	23:56	76.74	23:59	76.68	24:02	76.62	24:05	76.57	24:08
8-27-83	24:06	76.57	24:09	76.51	24:12	76.45	24:15	76.39	24:18	76.33	24:21	76.27	24:24	76.21	24:27	76.15	24:30	76.09	24:33
8-27-83	24:31	76.81	24:34	76.75	24:37	76.69	24:40	76.63	24:43	76.57	24:46	76.51	24:49	76.45	24:52	76.39	24:55	76.33	24:58
8-27-83	24:46	76.12	24:49	76.06	24:52	75.99	24:55	75.93	24:58	75.87	25:01	75.81	25:04	75.75	25:07	75.69	25:10	75.63	25:13
8-27-83	25:11	76.41	25:14	76.35	25:17	76.29	25:20	76.23	25:23	76.17	25:26	76.11	25:29	76.05	25:32	75.99	25:35	75.93	25:38
8-27-83	25:46	76.74	25:49	76.68	25:52	76.62	25:55	76.56	25:58	76.50	26:01	76.44	26:04	76.38	26:07	76.32	26:10	76.26	26:13
8-27-83	26:11	76.44	26:14	76.38	26:17	76.32	26:20	76.26	26:23	76.20	26:26	76.14	26:29	76.08	26:32	75.92	26:35	75.86	26:38
8-27-83	26:46	76.64	26:49	76.58	26:52	76.52	26:55	76.46	26:58	76.40	27:01	76.34	27:04	76.28	27:07	76.22	27:10	76.16	27:13
8-27-83	27:11	76.41	27:14	76.35	27:17	76.29	27:20	76.23	27:23	76.17	27:26	76.11	27:29	76.05	27:32	75.99	27:35	75.93	27:38
8-27-83	27:46	76.74	27:49	76.68	27:52	76.62	27:55	76.56	27:58	76.50	28:01	76.44	28:04	76.38	28:07	76.32	28:10	76.26	28:13
8-27-83	28:11	76.44	28:14	76.38	28:17	76.32	28:20	76.26	28:23	76.20	28:26	76.14	28:29	76.08	28:32	75.92	28:35	75.86	28:38
8-27-83	28:46	76.64	28:49	76.58	28:52	76.52	28:55	76.46	28:58	76.40	29:01	76.34	29:04	76.28	29:07	76.22	29:10	76.16	29:13
8-27-83	29:11	76.41	29:14	76.35	29:17	76.29	29:20	76.23	29:23	76.17	29:26	76.11	29:29	76.05	29:32	75.99	29:35	75.93	29:38
8-27-83	29:46	76.74	29:49	76.68	29:52	76.62	29:55	76.56	29:58	76.50	30:01	76.44	30:04	76.38	30:07	76.32	30:10	76.26	30:13
8-27-83	30:11	76.44	30:14	76.38	30:17	76.32	30:20	76.26	30:23	76.20	30:26	76.14	30:29	76.08	30:32	75.92	30:35	75.86	30:38
8-27-83	30:46	76.64	30:49	76.58	30:52	76.52	30:55	76.46	30:58	76.40	31:01	76.34	31:04	76.28	31:07	76.22	31:10	76.16	31:13
8-27-83	31:11	76.41	31:14	76.35	31:17	76.29	31:20	76.23	31:23	76.17	31:26	76.11	31:29	76.05	31:32	75.99	31:35	75.93	31:38
8-27-83	31:46	76.74	31:49	76.68	31:52	76.62	31:55	76.56	31:58	76.50	32:01	76.44	32:04	76.38	32:07	76.32	32:10	76.26	32:13
8-27-83	32:11	76.44	32:14	76.38	32:17	76.32	32:20	76.26	32:23	76.20	32:26	76.14	32:29	76.08	32:32	75.92	32:35	75.86	32:38
8-27-83	32:46	76.64	32:49	76.58	32:52	76.52	32:55	76.46	32:58	76.40	33:01	76.34	33:04	76.28	33:07	76.22	33:10	76.16	33:13
8-27-83	33:11	76.41	33:14	76.35	33:17	76.29	33:20	76.23	33:23	76.17	33:26	76.11	33:29	76.05	33:32	75.99	33:35	75.93	33:38
8-27-83	33:46	76.74	33:49	76.68	33:52	76.62	33:55	76.56	33:58	76.50	34:01	76.44	34:04	76.38	34:07	76.32	34:10	76.26	34:13
8-27-83	34:11	76.44	34:14	76.38	34:17	76.32	34:20	76.26	34:23	76.20	34:26	76.14	34:29	76.08	34:32	75.92	34:35	75.86	34:38
8-27-83	34:46	76.64	34:49	76.58	34:52	76.52	34:55	76.46	34:58	76.40	35:01	76.34	35:04	76.28	35:07	76.22	35:10	76.16	35:13
8-27-83	35:11	76.41	35:14	76.35	35:17	76.29	35:20	76.23	35:23	76.17	35:26	76.11	35:29	76.05	35:32	75.99	35:35	75.93	35:38
8-27-83	35:46	76.74	35:49	76.68	35:52	76.62	35:55	76.56	35:58	76.50	36:01	76.44	36:04	76.38	36:07	76.32	36:10	76.26	36:13
8-27-83	36:11	76.44	36:14	76.38	36:17	76.32	36:20	76.26	36:23	76.20	36:26	76.14	36:29	76.08	36:32	75.92	36:35	75.86	36:38
8-27-83	36:46	76.64	36:49	76.58	36:52	76.52	36:55	76.46	36:58	76.40	37:01	76.34	37:04	76.28	37:07	76.22	37:10	76.16	37:13
8-27-83	37:11	76.41	37:14	76.35	37:17	76.29	37:20	76.23	37:23	76.17	37:26	76.11	37:29	76.05	37:32	75.99	37:35	75.93	37:38
8-27-83	37:46	76.74	37:49	76.68	37:52	76.62	37:55	76.56	37:58	76.50	38:01	76.44	38:04	76.38	38:07	76.32	38:10	76.26	38:13
8-27-83	38:11	76.44	38:14	76.38	38:17	76.32	38:20	76.26	38:23	76.20	38:26	76.14	38:29	76.08	38:32	75.92	38:35	75.86	38:38
8-27-83	38:46	76.64	38:49	76.58	38:52	76.52	38:55	76.46	38:58	76.40	39:01	76.34	39:04	76.28	39:07	76.22	39:10	76.16	39:13
8-27-83	39:11	76.41	39:14	76.35	39:17	76.29	39:20	76.23	39:23	76.17	39:26	76.11	39:29	76.05	39:32	75.99	39:35	75.93	39:38
8-27-83	39:46	76.74	39:49	76.68	39:52	76.62	39:55	76.56	39:58	76.50	40:01	76.44	40:04	76.38	40:07	76.32	40:10	76.26	40:13
8-27-83	40:11	76.44	40:14	76.38	40:17	76.32	40:20	76.26	40:23	76.20	40:26	76.14	40:29	76.08	40:32	75.92	40:35	75.86	40:38
8-27-83	40:46	76.64	40:49	76.58	40:52	76.52	40:55	76.46	40:58	76.40	41:01	76.34	41:04	76.28	41:07	76.22	41:10	76.16	41:13
8-27-83	41:11	76.41	41:14	76.35	41:17	76.29	41:20	76.23	41:23	76.17	41:26	76.11	41:29	76.05	41:32	75.99	41:35	75.93	41:38
8-27-83	41:46	76.74	41:49	76.68	41:52	76.62	41:55	76.56	41:58	76.50	42:01	76.44	42:04	76.38	42:07	76.32	42:10	76.26	42:13
8-27-83	42:11	76.44	42:14	76.38	42:17	76.32	42:20	76.26	42:23	76.20	42:26	76.14	42:29	76.08	42:32	75.92	42:35	75.86	42:38
8-27-83	42:46	76.64	42:49	76.58	42:52	76.52	42:55	76.46	42:58	76.40	43:01	76.34	43:04	76.28	43:07	76.22	43:10	76.16	43:13
8-27-83	43:11	76.41	43:14	76.35	43:17	76.29	43:20	76.23	43:23	76.17	43:26	76.11	43:29	76.05	43:32	75.99	43:35	75.93	43:38
8-27-83	43:46	76.74	43:49	76.68	43:52	76.62	43:55	76.56	43:58	76.50	44:01	76.44	44:04	76.38	44:07	76.32	44:10	76.26	44:13
8-27-83	44:11	76.44	44:14	76.38	44:17	76.32	44:20	76.26											

Figure 15. Example Endeco hourly listing for Gage 2AB (sta P12AB)

the length of these data (56 days), an increment of 10 days was used. The y-axis values are also listed in Table 5 for each parameter. Finally, for the harmonic analysis plots, the x-axis range is either 0 to 864 hr or 0 to 144 hr per annotation. Again, because of the length of the NOAA data, the x-axis range is either 0 to 1,440 hr or 240 hr per annotation. Because of its greater variance, the y-axis range for these data is twice that of the TDR and Endeco gage harmonic analysis plots.

#### Data Editing

26. In general, the measured data were not edited as this would mask actual observed conditions. Thus, the tabular listings, which will be used for model verification, were not edited. For the plots, however, the TDR-2 pressure, surface elevation, and temperature data were edited, but this was of a minor nature. The TDR's occasionally produced bad records of 4 hr length (i.e., 48 data points at 5-min intervals). These bad records are filled with a value of "999.00" at each bad data point during initial processing to distinguish them from good data. The editing consisted of replacing these 999's with the value of the first previous good data point in the data array. On the plots, these edited values show up as a horizontal line of length equivalent to the number of consecutive bad hours or records replaced. Editing performed for the tidal harmonic analysis is described in paragraph 29.

#### Tidal Harmonic Analysis

27. Tidal harmonic analysis was performed on the NOAA tide data, TDR surface elevation data, and Endeco tidal current data. This analysis consisted of averaging, editing, filtering, and least square harmonic analysis to obtain tidal constituent amplitudes and local epochs.

##### Data averaging

28. The data were averaged to obtain hourly values before further analysis. The number of points averaged for the NOAA, TDR, and Endeco data were 10, 12, and 30, respectively.

##### Data editing

29. Spikes and missing data were replaced with the value of the previous good data point in a record. These error points were determined by

checking the data to see if they exceeded a user-specified tolerance level. For the tidal elevations, a value of 60 ft was used. Similarly, a tolerance level of 5 ft/sec was used for the current speed data. Finally, the mean was calculated and removed from the data before further processing.

#### Digital filtering

30. A digital band-pass filter was applied to attenuate low and high frequencies in the data. A period range of 3 to 26 hr was used in the harmonic analysis. Rapid changes in the wind field can cause short-term trends of less than 3 hr duration. Persistent winds of long duration, river outflows, and other solar- and lunar-induced sea level changes can produce long-term effects with periods greater than 26 hr.

31. An eight-pole Butterworth filter (Outlaw 1982) was applied to the data. This filter is characterized by a smooth power gain with maximum flatness in the passband and stopband and a reasonably sharp cutoff. The beginning and ending 50 points (i.e., hours) in each data set are affected by this filter and thus deleted.

#### Least squares harmonic analysis

32. According to Outlaw (1982), tidal elevation (or current speed) of the prototype tide (or current) at a station can be represented (Schureman 1958) by

$$h(t) = H_0 + \sum_{i=1}^J f_i H_i \cos [\bar{a}_i t + (v_o + u)_i - K_i] \quad (1)$$

where

$h$  = tidal elevation (current speed) at time  $t$

$t$  = time reckoned from some initial epoch

$H_0$  = mean height (speed) above reference datum

$J$  = total number of constituents

$f_i$  = node factor to reduce mean amplitude to year of prediction

$H_i$  = mean amplitude of  $i^{\text{th}}$  constituent

$\bar{a}_i$  = angular speed of  $i^{\text{th}}$  constituent

$v_o + u_i$  = equilibrium argument of the  $i^{\text{th}}$  constituent for  $t = 0$

$K_i$  = local epoch of  $i^{\text{th}}$  constituent

The coefficients  $f_i$ ,  $\bar{a}_i$ , and the equilibrium  $(v_o + u)_i$  can be obtained from tables in Schureman (1958). Equation 1 may be rewritten as

$$h(t) = H_0 + \sum_{i=1}^J A_i \cos(\omega_i t + \theta_i) \quad (2)$$

where

$A_i = f_i H_i$  = amplitude of the  $i^{th}$  constituent

$\omega_i$  = angular frequency of the  $i^{th}$  constituent

$\theta_i$  = phase of the  $i^{th}$  constituent

33. Observed prototype surface elevation (current speed) data  $h_p$  can be represented as

$$h_p(t) = \bar{h}_p(t) + \epsilon(t) = a_0 + \sum_{i=1}^J a_i \cos(\omega_i t) + b_i \sin(\omega_i t) + \epsilon(t) \quad (3)$$

where

$\bar{h}_p$  = calculated tidal elevation (current speed)  
represented by a harmonic series of known frequencies

$\epsilon(t)$  = noise in observed data

$a_0$ ,  $a_i$ , and  $b_i$  = coefficients

The noise level is not known, and the unknown coefficients (amplitudes and phases) are determined by minimizing the variance of the sum of the squared difference between the observed prototype tidal elevation (current speed) data and the form represented by Equation 2 using a least squares procedure.

34. The least square procedure minimizes the variance  $E$  such that

$$E = \sum_{i=1}^N \epsilon^2(n\Delta t) = \sum_{i=1}^N [\bar{h}_p(n\Delta t) - h_p(n\Delta t)]^2 \rightarrow \text{minimal} \quad (4)$$

where

$N$  = total number of data samples

$\Delta t$  = time interval (i.e. 1 hr) between consecutive samples

To minimize the variance, set

$$\frac{\partial E}{\partial a_i} = 0, \quad i = 1, \dots, J \quad (5)$$

and

$$\frac{\partial E}{\partial b_i} = 0, \quad i = 1, \dots, J \quad (6)$$

Algebraically, Equations 5 and 6 result in a set of simultaneous equations that may be solved for the  $a_i$  and  $b_i$  coefficients.

35. For each tidal constituent, the amplitude  $A_i$  and the phase  $\theta_i$  can be determined from

$$A_i = \left( a_i^2 + b_i^2 \right)^{1/2} \quad (7)$$

and

$$\theta_i = \arctan \left( \frac{b_i}{a_i} \right) \quad (8)$$

This calculated amplitude,  $A_i$ , is then corrected by dividing by a node factor,  $f_i$ , to obtain the value which is reported. The node factor is selected from the tables in Schureman (1958) for the middle of the year of measurement. The calculated phase angle  $\theta_i$  is also corrected by a procedure described in Schureman (1958) to obtain the local epoch.

36. The first step is to calculate the equilibrium argument for the meridian of Greenwich for each constituent corresponding to the year, month, day, and hour of the beginning of the filtered data:

$$(v_o + u)_{Gr} = (v_o + u)_{Yr} + (v_o + u)_{Mon} + (v_o + u)_{Day} + (v_o + u)_{Hr} \quad (9)$$

where

$(v_o + u)_{Gr}$  = Greenwich equilibrium argument

$(v_o + u)_{Yr}$  = equilibrium argument for the meridian of Greenwich at the beginning of a calendar year

$(v_o + u)_{Mon}$  = correction to equilibrium argument for the meridian of Greenwich at the beginning of a month

$(v_o + u)_{Day}$  = correction to equilibrium argument for the meridian of Greenwich at the beginning of a day

$(v_o + u)_{Hr}$  = correction to equilibrium argument for the meridian of Greenwich at the beginning of an hour

The last correction term for the beginning hour should be interpolated to the nearest minute to compensate for the beginning of the data after the averaging process and the first 50 hr are deleted due to filtering. The next step is to calculate the local equilibrium argument:

$$(v_o + u)_{Lo} = (v_o + u)_{Gr} - pL + \frac{as}{15} \quad (10)$$

where

$(V_o + u)_{Lo}$  = local equilibrium argument value  
p = coefficient of period for a particular constituent,  
number of periods in a constituent day  
L = longitude, positive west of Greenwich, deg  
a = angular speed of constituent, deg/solar hour  
s = longitude of time meridian, deg

Finally, the local epoch  $\kappa$  is given by

$$\kappa = (V_o + u)_{Lo} + \theta_i \quad (11)$$

#### Tidal constituents

37. Ten tidal constituents were used in the harmonic analysis of the tidal elevation and current data. Table 6 lists the periods for these constituents in descending order. Included are diurnal, semidiurnal, and shallow-water overtide components used by NOAA in their standard 29-day tidal harmonic analysis.\*

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\* Personal Communication, J. French, 1984, Predictions Branch, NOAA, Rockville, Md.

## PART IV: ANALYSIS RESULTS

### NOAA Tide Data

#### Surface elevation time series plot

38. Tidal heights from NOS's Daytona Beach, Florida, station (#8721120) were analyzed using CERC's tidal harmonic analysis program. The purpose was twofold: (a) to provide a reference for the tidal elevation and current harmonic analysis results, and (b) to verify the accuracy of the CERC computer program. Table 7 lists the sampling parameters for these data. Plate 1 is a time-series plot of the tidal elevations referenced to the original zero of the tide-staff datum. A "setting value" supplied by NOAA was added to the measured tidal heights in order to reference the heights to this station's datum. This is the datum used by NOS for harmonic analysis. Every 10 points were averaged to obtain hourly averages. The data are unedited, although they were checked for missing values.

#### Harmonic analysis plots

39. Plate 2 illustrates the results from the harmonic analysis of the NOAA data for the filtered prototype (measured) and constituent analysis (calculated) curves overlain on one graph. Plate 3 shows the corresponding tidal analysis residuals. The fit was very good with a root mean square (rms) error of 0.11.

40. Comparisons of the calculated constituent amplitudes and local epochs from these data were made with results from the NOS data for the full calendar year of 1974 from Daytona Beach pier using the full 37 constituents. Table 8 summarizes the values. The fit was generally very good when considering the disparity in the record lengths, the number of constituents which could be used in each analysis, and the seasonal and yearly changes. Also, hourly averages were used in the CERC analysis whereas NOS used only hourly points.

### Tidal Elevation Data

41. Presented in this report within Plates 4 through 19 are tidal elevation data which consist of pressure time-series plots, surface elevation time-series plots, and harmonic analysis plots for Gages T3 through T6. All

were measured with TDR-2 instruments. Table 7 lists the sampling parameters for the TDR's. Every 12 points were averaged to obtain hourly averages.

#### Pressure time-series plots

42. Plates 4 through 7 contain the gage pressure (i.e. pounds per square inch gage) plots for the four gages T3 through T6, respectively. The pressure range is from 2 to 8 psig, reflective of the different water depths.

#### Surface elevation time-series plots

43. The four surface elevation (depth) time-series plots (see Plates 8 through 11) range from approximately 5 to 24 ft. The height of the gage above bottom (see Table 2) was added to the converted pressure to obtain these values. Table 9 lists the maximum tidal elevation ranges and current speeds for each range. Range 4 had the largest tidal elevation range with a value of 3.5 ft.

#### Harmonic analysis plots

44. Plots from the harmonic analysis of the tidal elevation data are contained in Plates 12 through 19 for Gages T3 through T6. The first plot in each series of two for each gage is the overlain graph of filtered prototype (measured) and constituent analysis (computed) curves. The second plot is the tidal analysis residuals. Table 10 lists the constituent amplitudes, and Table 11 gives the local epochs (phases) for each tide gage. In general, the fit was very good for Gages T3 and T4 with rms error values of 0.07 and 0.08 ft, respectively. The fit was not as good for Gages T5 and T6, although still not bad with rms errors of 0.35 and 0.28 ft, respectively. Short-term, high-frequency fluctuations due to changes in the wind field or other local disturbances might have caused some of the disparity.

### Tidal Current Data

45. Tidal current data consist of the following:

- a. Current vector roses.
- b. Current vector "stick" plots.
- c. Current velocity magnitude time-series plots.
- d. Current direction time-series plots.
- e. Harmonic analysis plots.

These plots are grouped by type in Appendix C in ascending order for the 14 data sets 2AB to 5C, respectively. Table 7 lists the sampling parameters

for the Endeco current meters. Every 30 points were averaged to obtain hourly averages except for the current vector roses and vector stick diagrams.

#### Current vector roses

46. Plates 20 to 33 contain the current vector roses. In general, they illustrate the tidal influence on currents flowing in the inlet. For Range 2, the general trend is northeast to north-northeast ebb by southwest to south-southwest flood. For Range 3, the flow aligns itself quite strongly with a southeast ebb by northwest flood. Range 4 is characterized by a northeast ebb and a south-southwest flood. Finally, the general trend of Range 5 is a north-northwest ebb by a south-southeast flood. Gage 5C, however, aligns itself more with a northwest ebb and a southeast flood.

#### Current vector stick plots

47. These plots are similar to the current roses, except that they show the individual vectors as a time-series. They are contained in Plates 34 through 47. Directions are referenced in degrees from true north (top of page). The vectors are spaced 2 hr apart. Since the data are not edited or averaged, erroneous points show up as vectors with unreasonably large magnitudes or errant directions. In general, the ebb and flood directions match those indicated by the rose plots. For sta 2B, the date on which the impellers failed can be clearly seen. Table 9 summarizes the maximum current speed and corresponding tidal stage for each of the ranges measured. The largest ebb flow was 4.6 ft/sec for Range 2 (see Plates 34 and 37). The largest flood was recorded for Range 3 with a value of 3.0 ft/sec (see Plates 38 through 40).

#### Current velocity magnitude plots

48. Current velocity magnitude time-series plots are shown in Plates 48 through 61. The range is from 0 to 4 ft/sec. Averaged data at 1-hr intervals are plotted. Since it is unedited (i.e., raw) data, occasional spikes show up. The plotting program automatically clips any erroneous points greater than 4 ft/sec and resets them to this maximum value. Data sets 2BT, 3A, 4AB, 4BB, and 5B have some points which have been reset.

#### Current direction plots

49. Current direction time-series plots are shown in Plates 62 through 75. Plotted points represent hourly averages of unedited data. The influence of tides can be clearly seen by the cyclical reversal in direction. The data

are surprisingly good, with few spikes being apparent (see data sets 2BB, 3A, 4AB, and 5B).

#### Harmonic analysis plots

50. Because the records were too short because of damaged impellers, no harmonic analysis was performed on data sets 2BB and 2BT. Plates 76 through 99 contain the results from the harmonic analysis of the tidal current data for the remaining twelve data sets 2AB through 5C. The first plot in each series of two plots for each data set is the graph of overlain filtered prototype (measured) and constituent analysis (computed) curves. The second plot is the tidal analysis residuals. Table 12 shows the constituent amplitudes for each current gage. Table 13 lists the corresponding local epochs (phases) for each current gage. In general, the fits were good for current data with rms errors ranging from 0.18 to 0.40 ft/sec. The mean velocity values ranged from 0.68 to 1.81 ft/sec.

#### Temperature and Conductivity Data

51. Temperature data were collected by four TDR-2 stations and fourteen Endeco 174 stations. Conductivity was measured at the Endeco stations only. Plots of these data are contained in Plates 100-133.

#### TDR temperature plots

52. The temperature data (see Plates 100 through 103) were remarkably consistent for the four TDR gages on Ranges 3 through 6. The range in values was from approximately 24° to 28.5° C. The following general trend in temperature cycling is reflected in each of the four stations:

- a. Declines for 2 days from 25.5° to 24° C.
- b. Builds up to a maximum of 28.5° C over a 10-day period.
- c. Declines to 25° C for 7 days.
- d. Finally begins rising back to 27° C over a 3-day period.

#### Endeco temperature plots

53. Fourteen plots of temperature from the Endeco 174 current meters, Gages 2AB to 5C, respectively, are contained in Plates 104 through 117. The range in temperature values is 22.5° to 27.5° C. The same general trend is illustrated for all stations and is consistent with the results obtained by the TDR gages. The temperature does the following:

- a. Slowly rises over a 10-day period from 24° to 27.5° C.
- b. Declines for 7 days to 25.5° C.
- c. Rises momentarily over 3 days to 27° C.
- d. Falls off over 7 days to a low of 22.5° C.
- e. Finally begins another cycle of 4 days to 24° C before declining again.

#### Conductivity plots

54. Conductivity plots for the fourteen Endeco 174 stations are contained in Plates 118 through 131. In general, values range from 30 to 55 mmho/cm, with one cycle lasting for 16 days and another cycle for 3 weeks with a transition period of 3 to 7 days in between. The same consistency does not exist among all data sets, or even at the same location, as it did for the temperature data.

## PART V: SUMMARY

55. Tidal elevation and current data were measured and analyzed at Ponce de Leon Inlet for use in calibrating model studies that will evaluate alternative improvements to the weir-jetty system.

56. Data were successfully obtained from four of six Sea Data TDR-2 pressure sensors and 14 Endeco 174 current meters during the period September to November 1983. Quality of the data was excellent with very few spikes or missing points. Hardware-related problems occurred on the TDR for Gage T7 due to flooding. Two of the Endeco gages at sta 2B lost their impellers due to high sediment and current flows and/or fishing activity in the inlet throat.

57. Tidal harmonic analysis of 56 days of NOS tide data, using CERC's software, verified the accuracy of the program and provided a reference for tidal elevation and current harmonic analysis results. The rms error was 0.11 ft. Constituent amplitudes and local epochs for 10 constituents agreed quite well with NOS's data for the full calendar year of 1974 from Daytona Beach pier using 37 constituents.

58. Pressure and surface elevation time series and harmonic analysis plots are presented for tidal elevation data collected in Ranges 3 through 6. Mean water depths ranged from 5.46 to 23.00 ft. The maximum tidal range was 3.5 ft at Range 4. The harmonic analysis results were very good for Ranges 3 and 4 with rms errors of 0.07 and 0.08 ft, respectively. For Ranges 5 and 6, the rms errors were higher at 0.35 and 0.28, respectively, but still very good.

59. For the tidal current data, current roses, vector stick plots, current velocity magnitude time-series, current direction time-series, and harmonic analysis plots are presented. The maximum velocity recorded was 3.0 ft/sec at Range 3.0 for flood flow and 4.6 ft/sec at Range 2 for ebb flow. In general, these values are consistent with those reported earlier.

60. Temperature data were remarkably consistent between TDR and Endeco gages, showing the same general trends. The range of temperatures was approximately 22.5° to 28.5° C.

61. Conductivity data were recorded by the Endeco current meters and ranged from approximately 30 to 55 mmho/cm.

## REFERENCES

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- Outlaw, D. G. 1982. "Lake Pontchartrain and Vicinity Hurricane Protection Plan, Report 1, Prototype Data Acquisition and Analysis," Technical Report HL-82-2, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.
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Table 1  
Tidal Ranges from National Ocean Survey Tide Tables

<u>Station</u>	<u>Mean Range ft</u>	<u>Spring Range ft</u>
Daytona Beach	4.1	4.9
Ponce de Leon Inlet	2.3	2.7

Table 2  
Summary of Instrument Locations

<u>Station Number</u>	<u>ID Number</u>	<u>Description</u>	<u>Height Above Bottom, ft</u>	<u>Mean Depth ft</u>	<u>Mean Elevation Reference msl ft</u>
<u>Tide Gages</u>					
T1-2	153	United States Coast Guard dock	1.69	--	--
T3	159	Down the Hatch Restaurant	0.60	5.89	0.53
T4	152	Day Marker 10 in ICCW	12.95	23.00	0.45
T5	154	Christian's Pier, 1720 N. Indian River	1.65	5.46	0.29
T6	158	Smyrna Yacht Club	1.45	4.58	0.60
T7	157	1st pier north of Bascule Bridge	3.15	--	--
<u>Gage Number</u>	<u>ID Number</u>	<u>Description</u>			
<u>Current Meters</u>					
2AT*	174A080	Inlet throat, south of channel, 1/3 water depth			
2AB	174A079	Inlet throat, south of channel, 2/3 water depth			
2BT	174A090	Inlet throat, north of channel, 1/3 water depth			
2BB	174A088	Inlet throat, north of channel, 2/3 water depth			
3A	174A085	Halifax River, west gage, 1/2 water depth			
3B	174A082	Halifax River, center gage, 1/2 water depth			
3C	174A075	Halifax River, east gage, 1/2 water depth			
4AT	174A077	Rockhouse Creek, south of channel, 1/3 water depth			
4AB	174A092	Rockhouse Creek, south of channel, 2/3 water depth			
4BT	174A084	Rockhouse Creek, north of channel, 1/3 water depth			
4BB	174A076	Rockhouse Creek, north of channel, 2/3 water depth			
5A	174A087	Indian River, west gage, 1/2 water depth			
5B	174A078	Indian River, center gage, 1/2 water depth			
5C	174A091	Indian River, east gage, 1/2 water depth			

**\*Legend:**

2 = Range 2.

2A = Station 2A.

T = Top Gage.

B = Bottom Gage.

Table 3  
Current Measurements, 27 January 1984

Station 1A				Station 1B			
Time EST	Depth ft	Velocity ft/sec	Direction deg	Time EST	Depth ft	Velocity ft/sec	Direction deg
0745	5	2.9	80	0730	8	3.2	75
0746	11	2.7	80	0732	17	2.5	105
0837	6	3.4	80	0830	8	3.5	90
0838	11	3.0	80	0831	17	3.7	90
0920	6	2.7	60	0916	8	3.9	72
0921	11	2.5	75	0918	17	3.0	90
1015	5	2.4	75	1011	7	3.5	80
1016	11	2.4	80	1012	14	3.7	90
1124	5	1.6	100	1118	8.5	2.2	75
1125	11	1.9	110	1119	18	2.0	90
1215	5	1.5	60	1211	8	1.2	90
1216	10	1.0	135	1212	17	1.7	90
1315	5	0.8	90	1311	7.5	0.8	65
				1312	16	0.8	5
1422	5	0.8	340	1418	8	0.8	335
1423	11	1.5	270	1419	16	1.4	285
1516	6	1.4	345	1513	9	1.5	255
				1514	18	1.4	285
1616	5.5	1.4	270	1610	9	1.4	280
1617	11	1.3	230	1611	18	1.2	290
1713	6	1.2	210	1709	8	1.0	255
1714	11	1.0	205	1710	18	0.7	275
1804	6	0.8	135	1800	9	0.8	175
1805	12	1.0	120	1801	18	1.0	150
0715	3	1.9	45	0700	6	2.5	105
0716	7	2.9	30	0701	12	2.2	105
0807	5	3.0	15	0755	6	4.2	35
0808	11	3.2	35	0756	12	2.8	44
0906	5.5	3.5	28	0900	6	3.4	30
0907	11	3.5	28	0902	13	3.8	40

(Continued)

Table 3 (Concluded)

Station 1A				Station 1B			
Time EST	Depth ft	Velocity ft/sec	Direction deg	Time EST	Depth ft	Velocity ft/sec	Direction deg
1005	4	3.7	30	1001	6	2.9	32
1006	9	3.9	32	1002	13	3.2	55
1113	4	2.9	30	1100	6	2.7	30
1115	8	2.5	28	1101	12	2.2	45
1202	4	2.1	20	1159	6	1.6	15
1203	8	2.1	20	1200	12	2.8	45
1304	4	0.8	45	1300	6	1.0	345
1405	4	2.9	210	1401	5	2.5	210
1406	9	1.7	202	1402	10	2.9	260
1506	5	2.0	210	1500	6	2.2	215
1507	11	2.2	210	1501	13	2.7	220
1602	6	2.2	210	1558	6	2.0	210
1603	11	2.0	195	1559	11	1.9	225
1701	4	1.9	210	1656	5	1.0	195
1703	10	1.7	210	1658	11	1.5	225
1751	5	0.7	270	1748	5	0.8	210
1752	11	0.8	200	1749	11	0.9	205

Table 4  
Summary of Data Collection from  
September through November, 1987

<u>Station</u>	<u>Start Date</u>	<u>End Date</u>	<u>Duration Days</u>	Number of Records		<u>Percent Recovery</u>
				Total	Bad	
<u>Tide Data</u>						
T1-2	9/27	10/8	11	66	49	25.8
T3	9/27	10/20	23	135	2	98.5
T4	9/27	10/24	27	160	5	96.9
T5	9/27	10/24	27	162	29	82.1
T6	9/27	10/23	26	155	7	95.5
T7	9/28		Water damaged			0.0
<u>Current Data</u>						
2AB*	9/30	11/7	38	916	3	99.7
2AT**	9/30	11/7	38	916	3	99.7
2BB	9/30	11/8	39	939	2	99.8
2BT	9/30	11/8	39	941	2	99.8
3A	9/28	11/7	41	982	99	89.9
3B	9/28	11/7	40	965	2	99.8
3C	9/28	11/7	40	966	3	99.7
4AB	9/29	11/8	40	968	3	99.7
4AT	9/29	11/8	40	969	4	99.6
4BB	9/29	11/8	40	968	3	99.7
4BT	9/29	11/8	27	639	39	93.9
5A	9/29	11/7	39	938	3	99.7
5B	9/29	11/7	37	890	2	99.8
5C	9/29	11/7	39	938	4	99.6

\*2AB = Station 2A, bottom current meter.

\*\*2AT = Station 2A, top current meter.

Table 5  
Summary of Plot Formats

Parameter	Source	x-Axis		y-Axis	
		Range	Units	Range	Units
Reference mllw* datum height	NOAA** TDR	9/27 to 12/7 9/27 to 11/16	Calendar date Calendar date	0 to 40 0 to 40	ft ft
Surface elevation					
Pressure	TDR	9/27 to 11/16	Calendar date	0 to 10	psig
Current vector rose	Endeco	NA	NA	0 to 3.5	ft/sec
Current vector	Endeco	9/27 to 11/16	Calendar date	-5.0 to 5.0	ft/sec
Current velocity magnitude	Endeco	9/27 to 11/16	Calendar date	-1.0 to 4.0	ft/sec
Current direction	Endeco	9/27 to 11/16	Calendar date	0 to 450	deg true
					north
Tidal elevation constituents	NOAA	0 to 1440	Hours	-4.0 to 4.0	ft
Tidal elevation residuals	NOAA	0 to 1440	Hours	-4.0 to 4.0	ft
Tidal elevation constituents	TDR	0 to 864	Hours	-2.0 to 2.0	ft
Tidal elevation residuals	TDR	0 to 864	Hours	-2.0 to 2.0	ft
Tidal current constituents	Endeco	0 to 864	Hours	-2.0 to 2.0	ft/sec
Tidal current residuals	Endeco	0 to 864	Hours	-2.0 to 2.0	ft/sec
Temperature	TDR	9/27 to 11/16	Calendar date	20 to 30	°C
Temperature	Endeco	9/27 to 11/16	Calendar date	20 to 30	°C
Conductivity	Endeco	9/27 to 11/16	Calendar date	20 to 70	mmho/cm

\* Mean low lower water.

\*\* National Oceanic Atmospheric Administration.

Table 6  
Tidal Harmonic Constituents

<u>Constituent No.</u>	<u>Harmonic Constituent</u>	<u>Symbol</u>	<u>Period, hr</u>
1	Principal lunar diurnal	O1	25.819
2	Lunisolar diurnal	K1	23.934
3	Larger lunar elliptic	N2	12.658
4	Principal lunar	M2	12.421
5	Principal solar	S2	12.000
6	Lunar overtide	M4	6.210
7	Solar quarterdiurnal	S4	6.000
8	Lunar overtide	M6	4.140
9	Solar overtide	S6	4.000
10	Lunar overtide	M8	3.105

Table 7  
Standard Sampling Parameters

NOAA, Daytona Beach

Period measured	6 Oct to 30 Nov 1983
Duration, days	56
Sampling interval, min	6

TDR-2

Period measured	30 Sep to 7-8 Nov 1983
Sampling interval, min	5

Endeco 17!

Period measured	29-30 Sep to 7-8 Nov 1983
Sampling interval, min	2
Angle, deg Magnetic North to True North	3.25

Table 8  
Comparison of National Oceanic Atmospheric Administration  
Tide Data Daytona Beach Pier versus Coastal Engineering  
Research Center Analysis

Constituent No.	Constituent	Amplitude, ft		Local Epoch, deg	
		NOAA	CERC	NOAA	CERC
1	O1	0.24	0.19	120.9	136.0
2	K1	0.32	0.27	116.8	121.1
3	N2	0.47	0.38	187.5	213.1
4	M2	1.87	1.83	209.8	239.7
5	S2	0.32	0.34	231.6	246.6
6	M4	--	0.03	--	156.0
7	S4	--	0.02	--	291.4
8	M6	--	0.02	--	304.0
9	S6	--	0.01	--	222.6
10	M8	--	0.00	--	58.9

Notes: CERC analysis parameters:

Record length, 56 days

Record length, 1,333 hr

Residual rms, 0.11 ft

Mean elevation, 4.88 ft

The symbol (--) means amplitude values are insignificant for this component.

Start time of data: 6 Oct 1983, 1254 hr EST and end time of data: 1 Dec 1983, 0912 hr EST. Filtered average start time of data: 8 Oct 1983, 1621 hr EST and filtered average end time of data: 29 Nov 1983, 0842 hr EST.

Table 9  
Summary of Maximum Tidal Ranges and Currents

<u>Range</u>	<u>Maximum Tidal Range ft</u>	<u>Maximum Current Speed ft/sec</u>	<u>Tidal Stage for Maximum Speed</u>
1	--	3.9*	Ebb
2	--	4.6	Ebb
3	3.3	3.0	Flood
4	3.5	2.8	Flood
5	3.4	2.5	Flood
6	2.8	--	--
7	Failed	--	--

\* Measured by an Endeco 110 current meter.

Table 10  
Constituent Amplitudes for Tidal Elevations

Tide Gage	Record Length Days	Hours	Constituent Amplitudes, ft								Residual rms ft	Mean Depth ft	
			01	K1	N2	M2	S2	M4	S4	M6	S6	M8	
T1-2													
T3	22	521	0.13	0.15	0.26	1.06	0.20	0.03	0.02	0.03	0.00	0.01	0.07
T4	26	613	0.13	0.17	0.24	1.14	0.22	0.04	0.02	0.03	0.00	0.01	0.08
T5	25	591	0.12	0.11	0.73	0.58	0.36	0.04	0.02	0.00	0.02	0.00	0.35
T6	25	583	0.10	0.09	0.53	0.73	0.24	0.04	0.02	0.04	0.01	0.00	0.28
T7												Water Damaged	.

Table 11

Local Epochs for Tidal Elevations

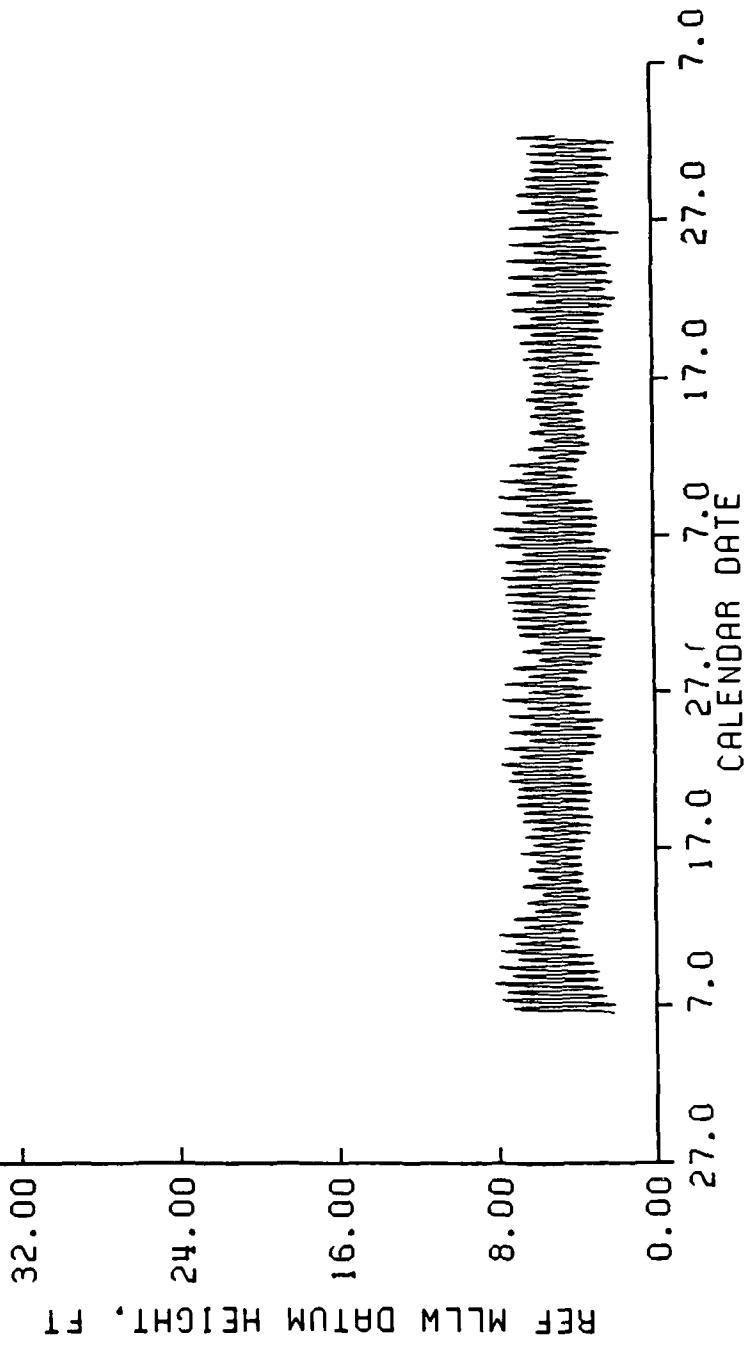
Tide Gage	<u>01</u>	<u>K1</u>	<u>N2</u>	<u>M2</u>	Local Epoch, deg				<u>S6</u>	<u>M8</u>
	<u>S2</u>	<u>M4</u>	<u>S4</u>	<u>M6</u>						
T1-2					Not Enough Data					
T3	266.1	258.3	95.1	131.8	165.6	212.5	139.9	143.8	141.9	259.4
T4	208.6	205.7	338.3	13.3	37.1	330.1	262.0	140.2	142.1	153.5
T5	78.2	117.7	43.9	89.6	144.7	113.3	168.1	76.3	359.6	299.2
T6	161.8	138.2	208.8	196.8	319.1	13.8	17.6	45.7	166.0	302.4
T7					Water Damaged					

Table 12  
Constituent Amplitudes for Tidal Currents

Current Gage	Record Length Days	Hours	Constituent Amplitude, ft/sec						Residual rms ft	Mean Elevation ft	
			01	K1	M2	S2	M4	S4	M6	S6	M8
2AB	37	875	0.08	0.12	0.03	0.31	0.05	0.70	0.04	0.19	0.05
2AT	35	819	0.09	0.12	0.04	0.37	0.07	0.84	0.05	0.18	0.06
2BB							Damaged				
2BT							Damaged				
3A	38	911	0.05	0.04	0.03	0.16	0.02	0.16	0.04	0.08	0.02
3B	40	945	0.09	0.10	0.02	0.12	0.02	0.58	0.01	0.10	0.02
3C	37	885	0.09	0.11	0.05	0.17	0.04	0.58	0.04	0.09	0.03
4AB	40	949	0.08	0.14	0.05	0.43	0.06	0.52	0.00	0.06	0.02
4AT	40	943	0.10	0.15	0.07	0.37	0.08	0.61	0.00	0.07	0.03
4BB	40	947	0.07	0.09	0.02	0.23	0.05	0.41	0.02	0.06	0.02
4BT	22	519	0.08	0.10	0.04	0.10	0.02	0.50	0.01	0.11	0.03
5A	38	907	0.04	0.05	0.04	0.13	0.03	0.31	0.03	0.02	0.02
5B	37	869	0.05	0.04	0.05	0.11	0.00	0.41	0.03	0.03	0.02
5C	38	913	0.06	0.11	0.03	0.08	0.03	0.47	0.02	0.06	0.05

Table 13  
Local Epochs for Tidal Currents

PONCE DE LEON INLET PROJECT  
NOAA TIDE GAGE STATION NOAA  
EDITED 1 HOUR AVERAGES, OCT TO NOV '83



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
TIDE GAGE, STATION NOAA, OCT TO NOV '83

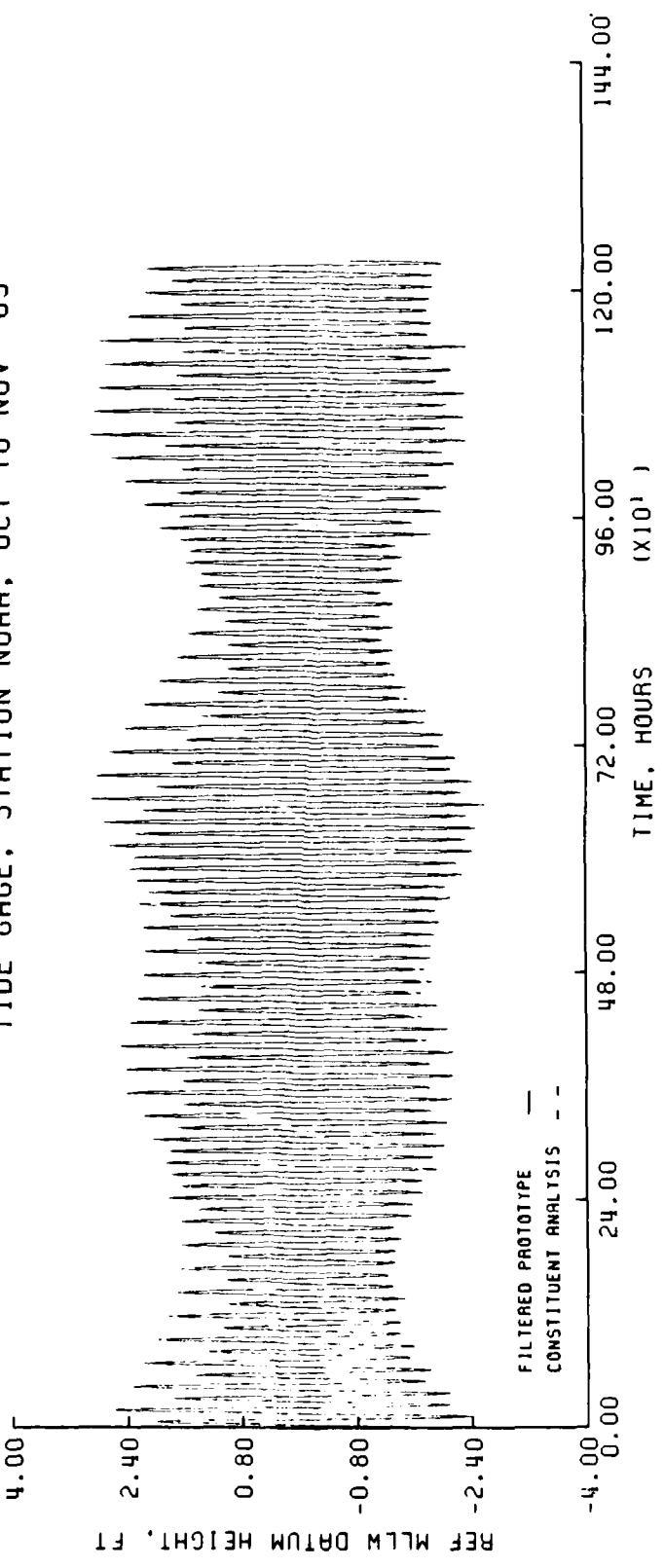
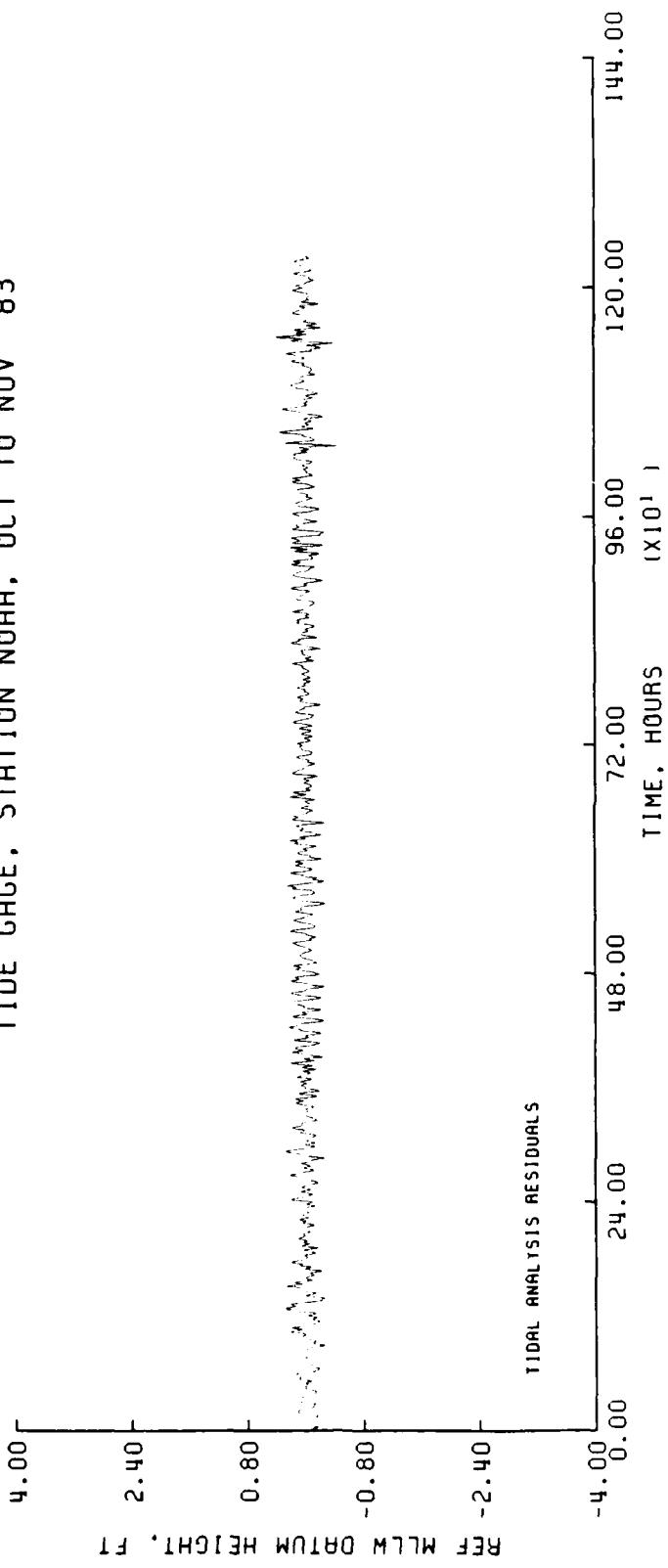


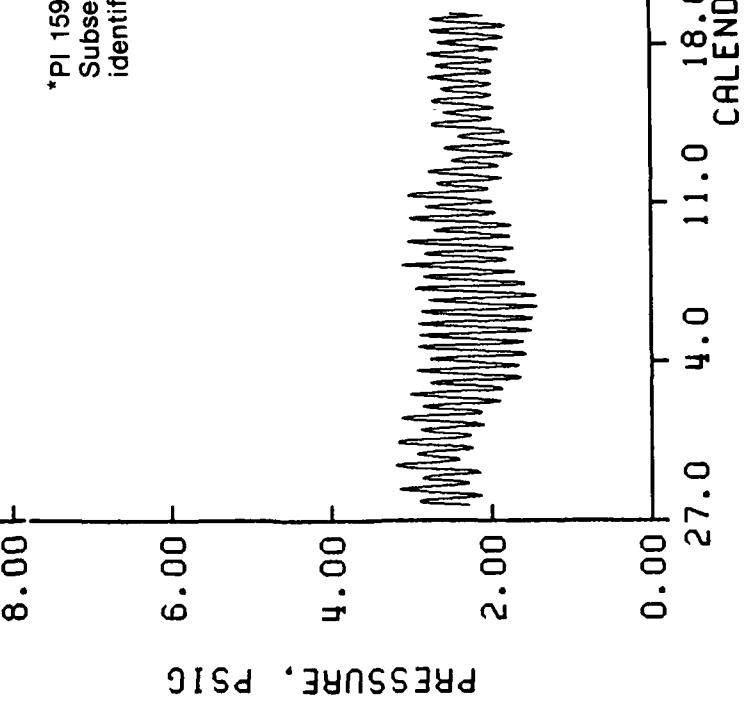
PLATE 2

TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
TIDE GAGE, STATION NOAA, OCT TO NOV '83



PONCE DE LEON INLET PROJECT  
TDR-2, STATION PI 159\*  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83

\*PI 159 = Station T3; See Table 2.  
Subsequent tide stations also  
identified on Table 2.



PONCE DE LEON INLET PROJECT  
TDR-2, STATION P115<sup>2</sup>  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83

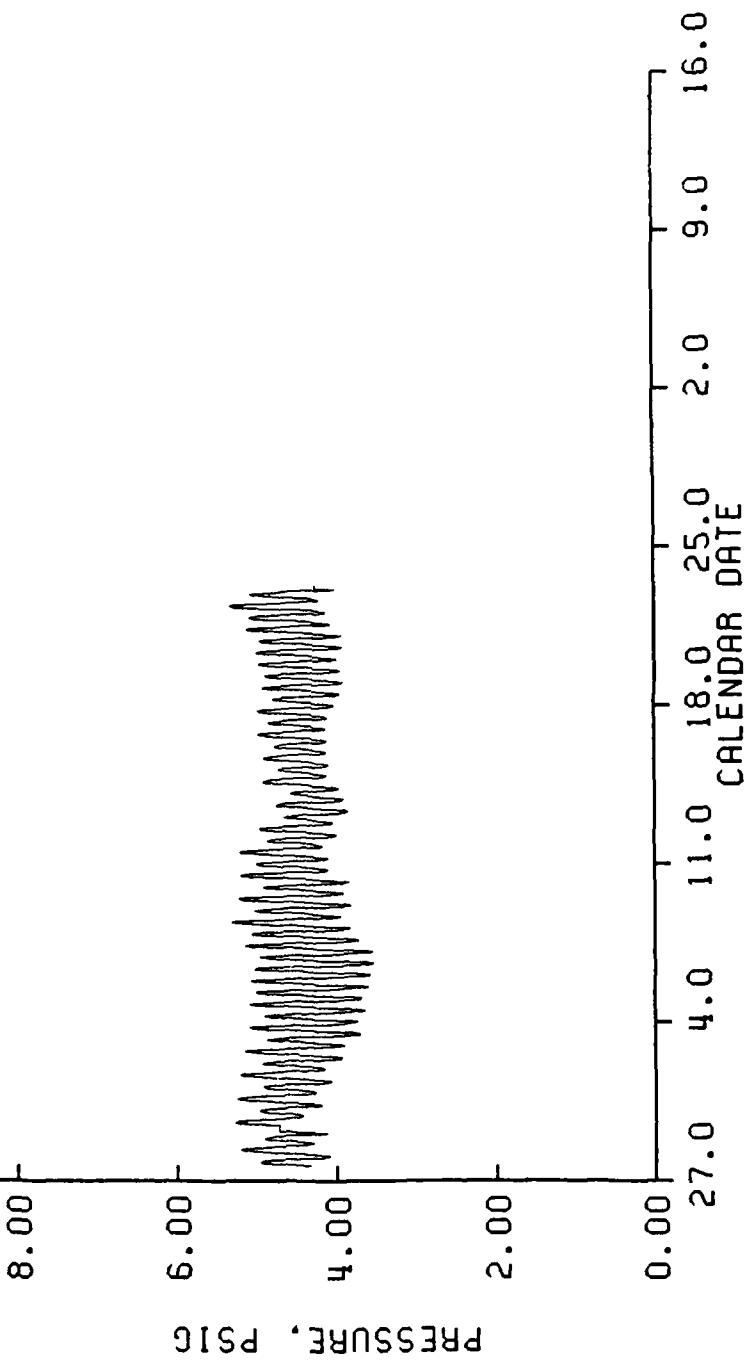
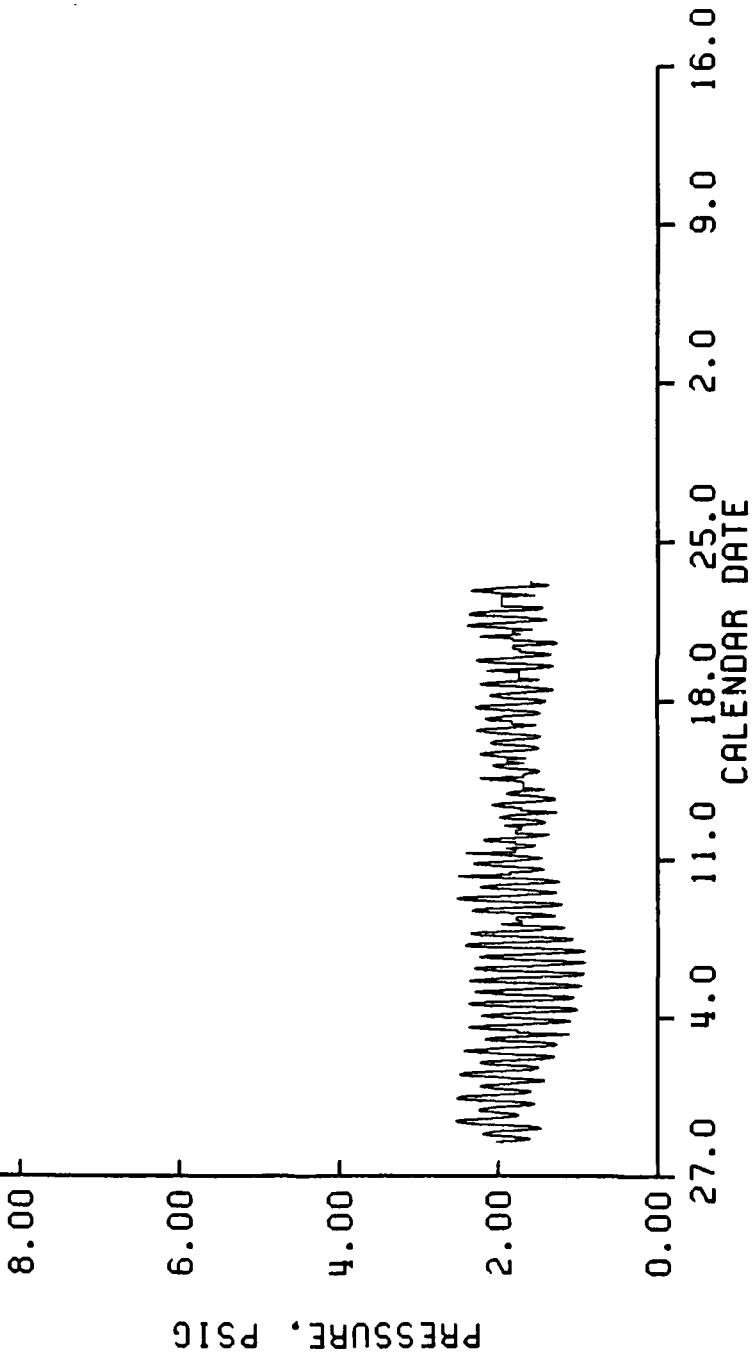


PLATE 5

PONCE DE LEON INLET PROJECT  
TDR-2, STATION PI154  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83



PONCE DE LEON INLET PROJECT  
TOR-2, STATION PI158  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83

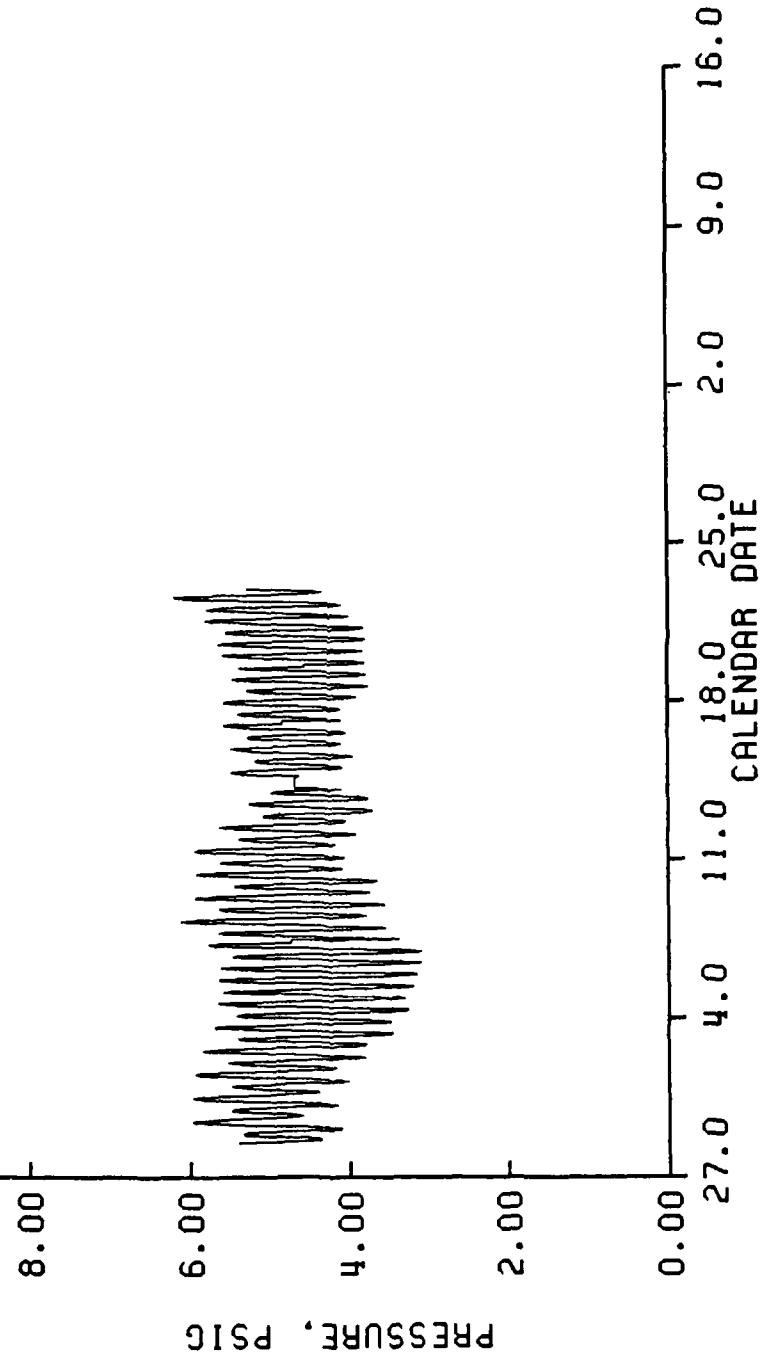
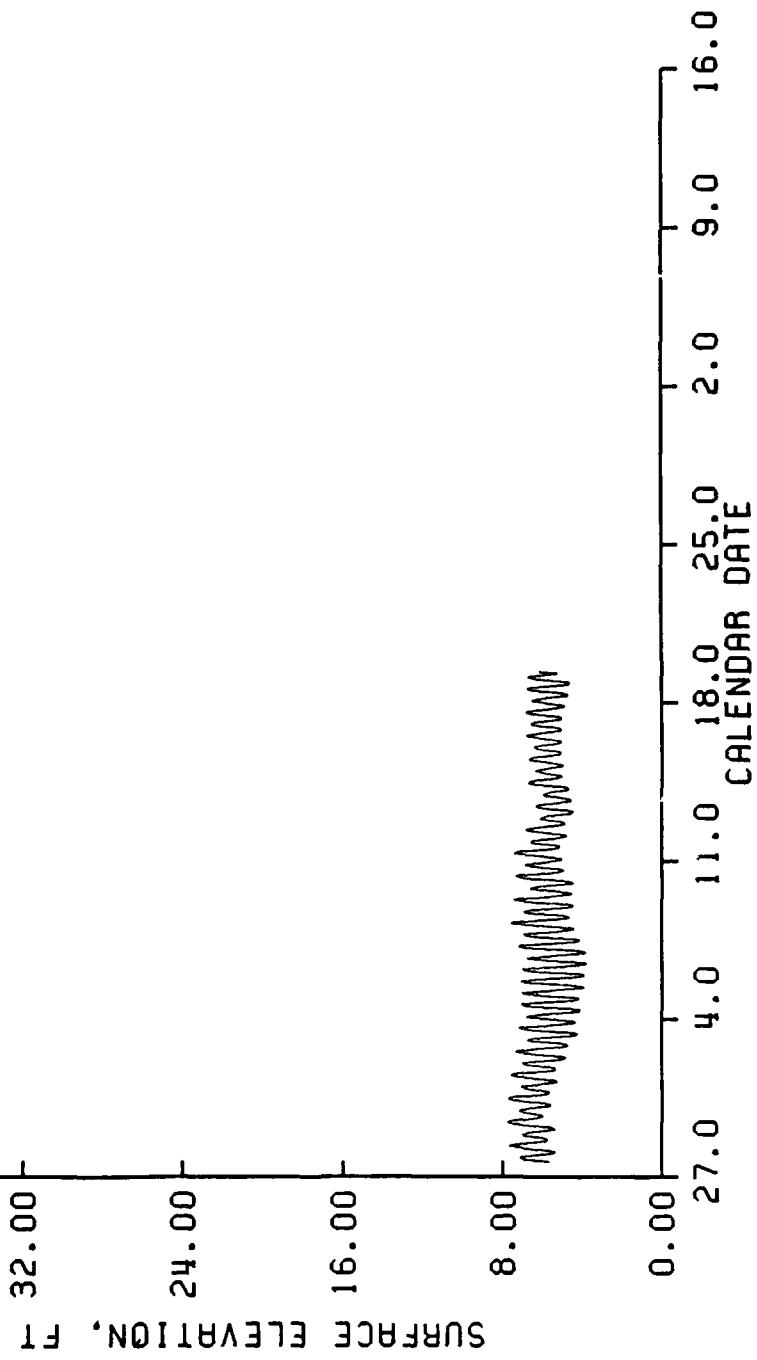
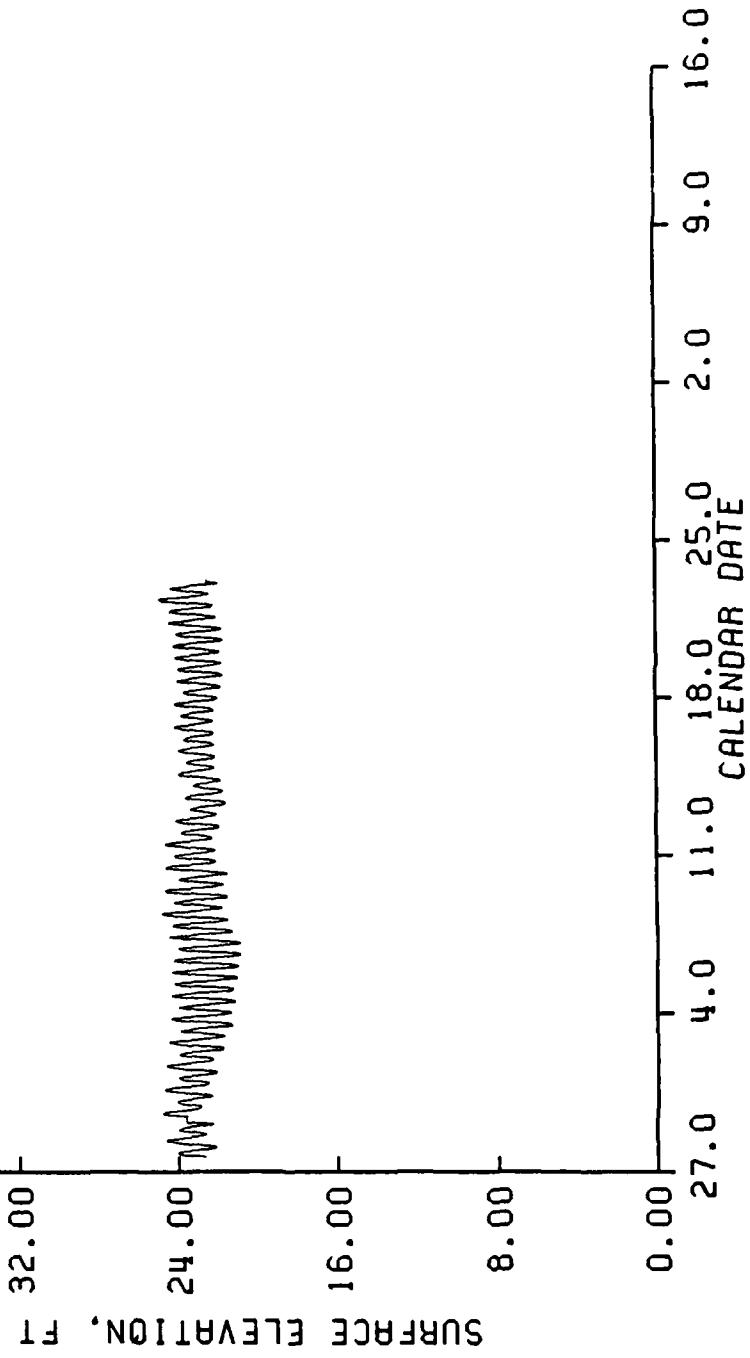


PLATE 7

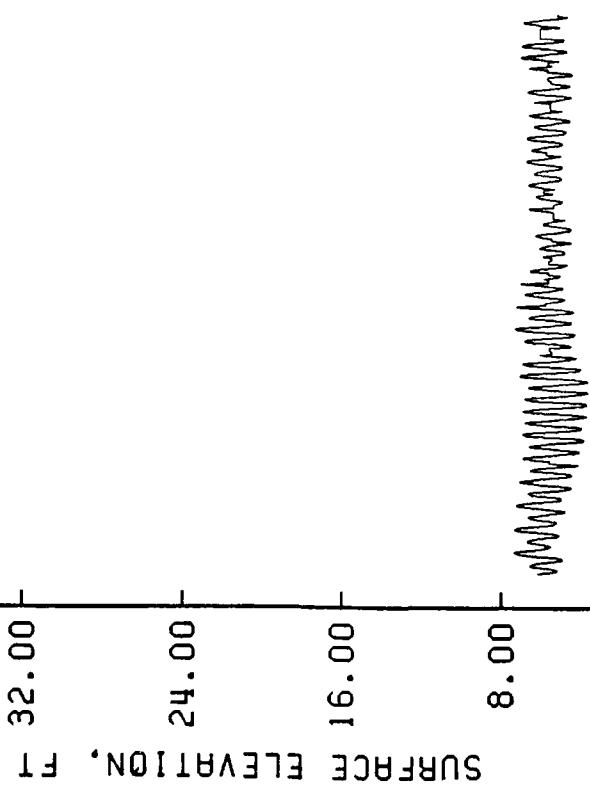
PONCE DE LEON INLET PROJECT  
TDR-2, STATION PI159  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83



PONCE DE LEON INLET PROJECT  
TDR-2 STATION PI152  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83



PONCE DE LEON INLET PROJECT  
TDR-2, STATION PI154  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83



PONCE DE LEON INLET PROJECT  
TOR-2, STATION PI158  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83

40.00  
32.00  
24.00  
16.00  
8.00  
0.00  
SURFACE ELEVATION, FT

27.0 4.0 11.0 18.0 25.0 2.0 9.0 16.0  
CALENDAR DATE

TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
TDR-2, STATION P1159, SEPT 10 NOV '83

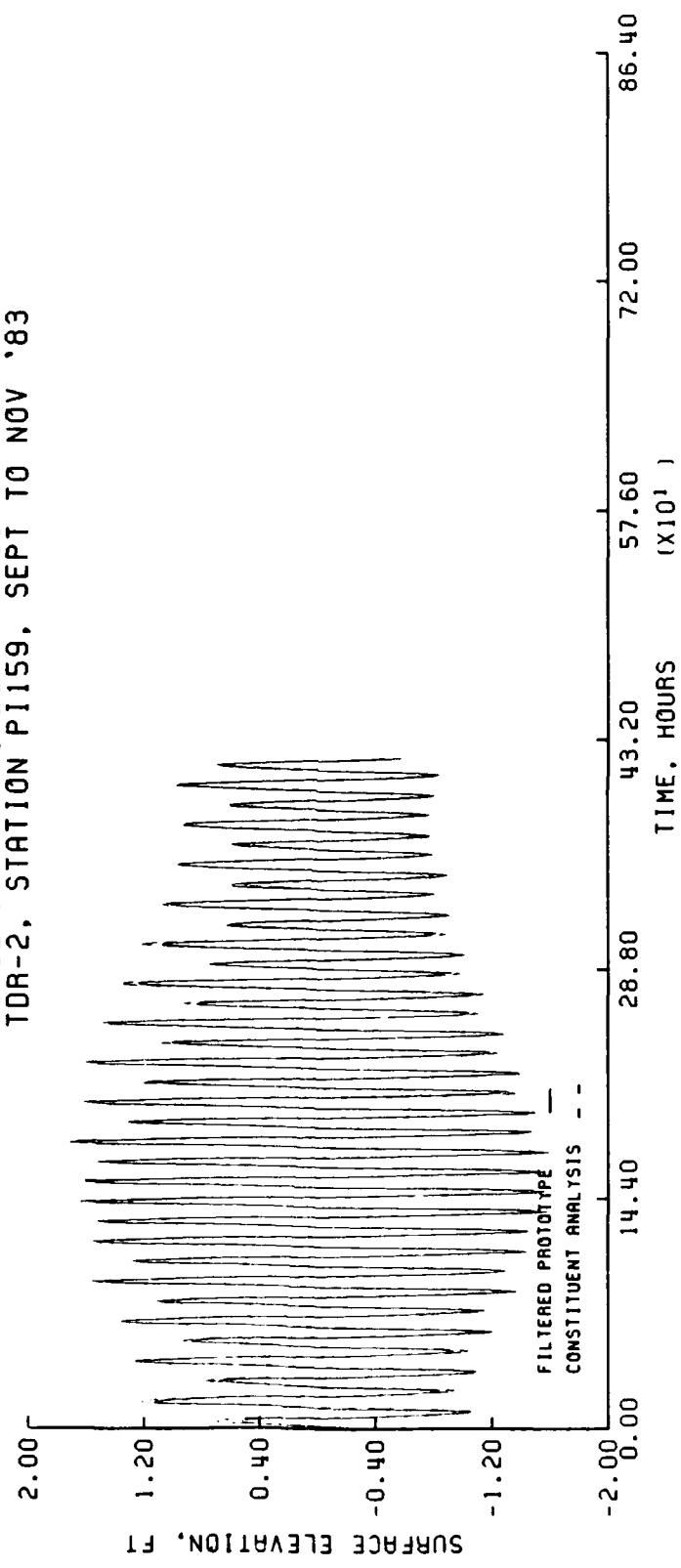
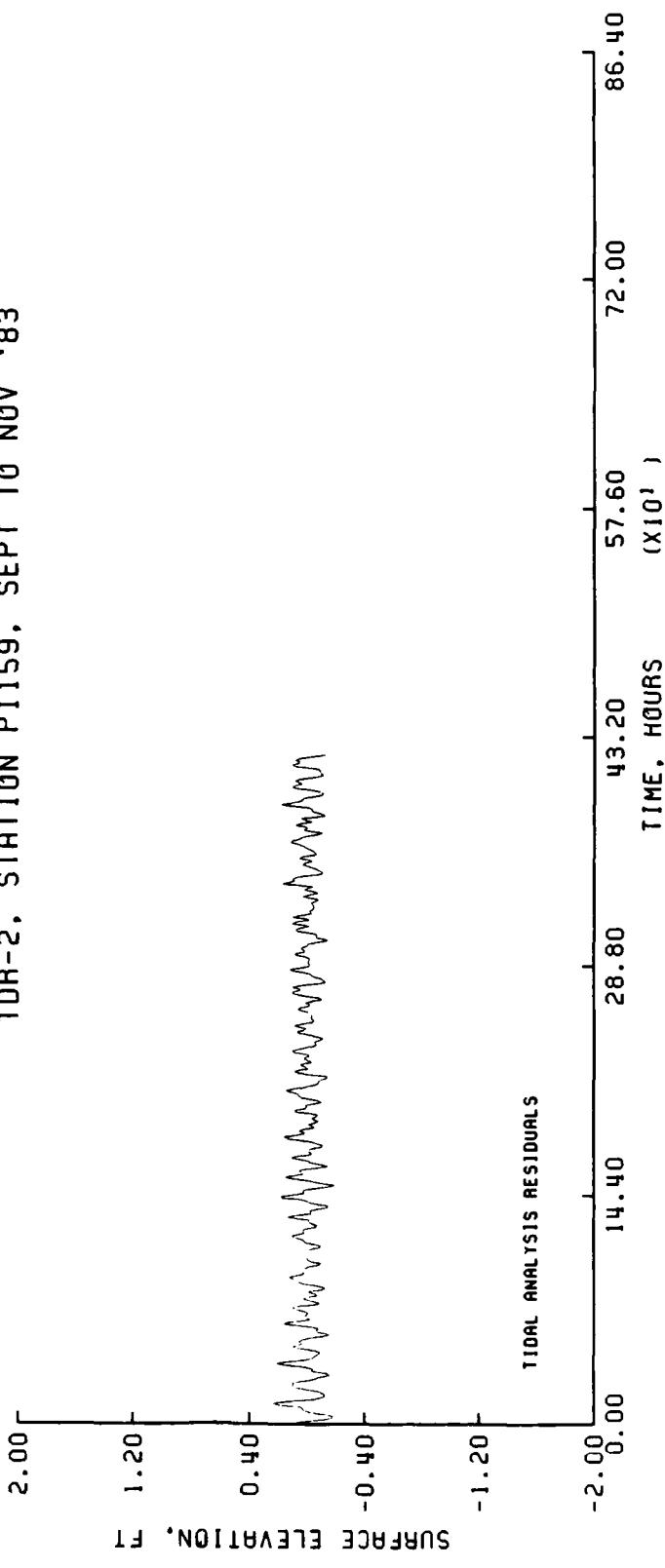
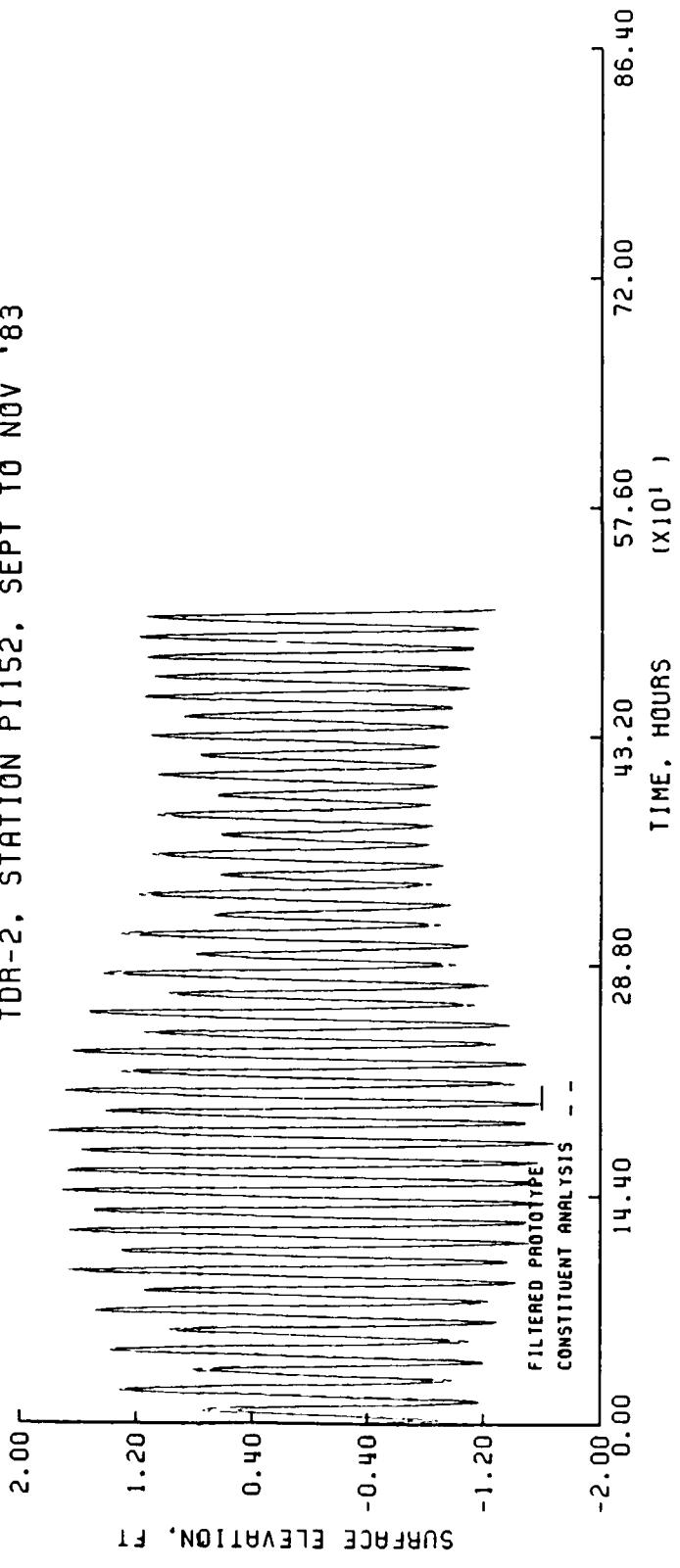


PLATE 12

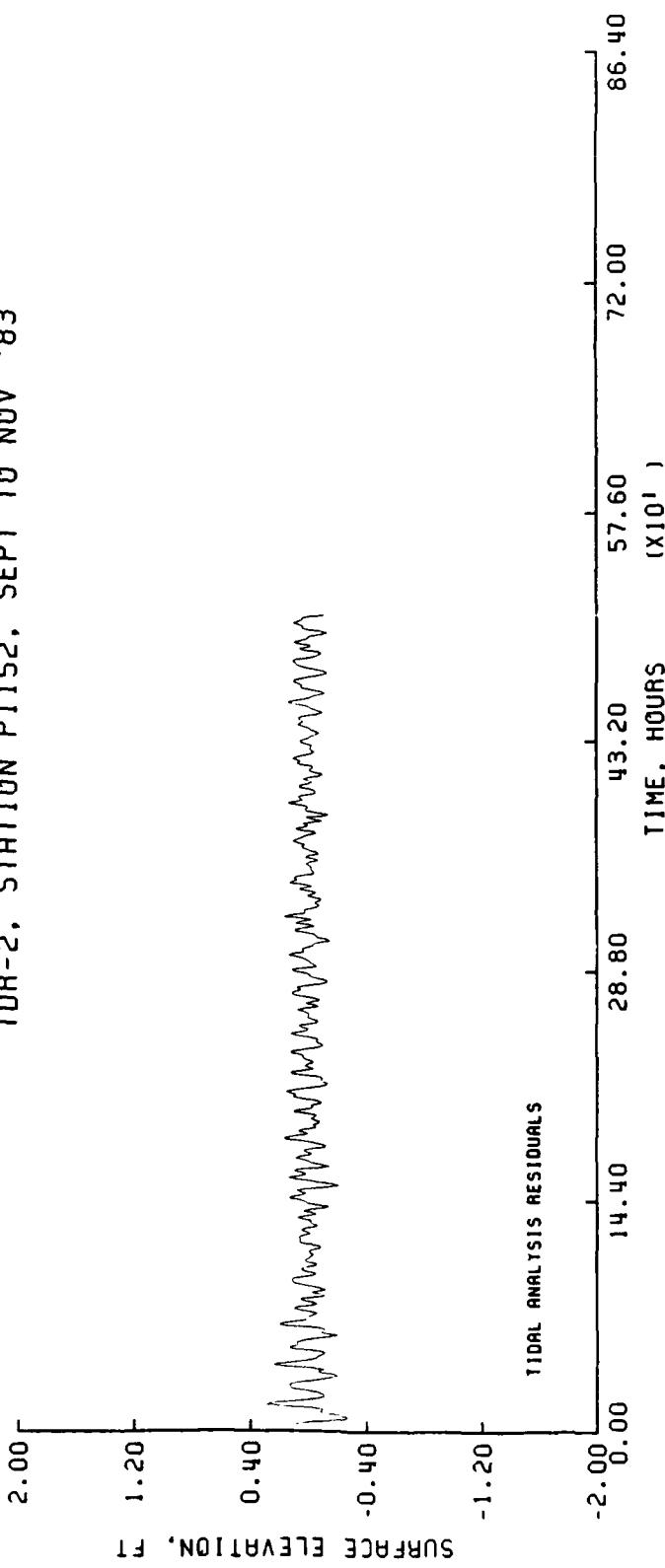
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TOR-2, STATION P1159, SEPT TO NOV '83



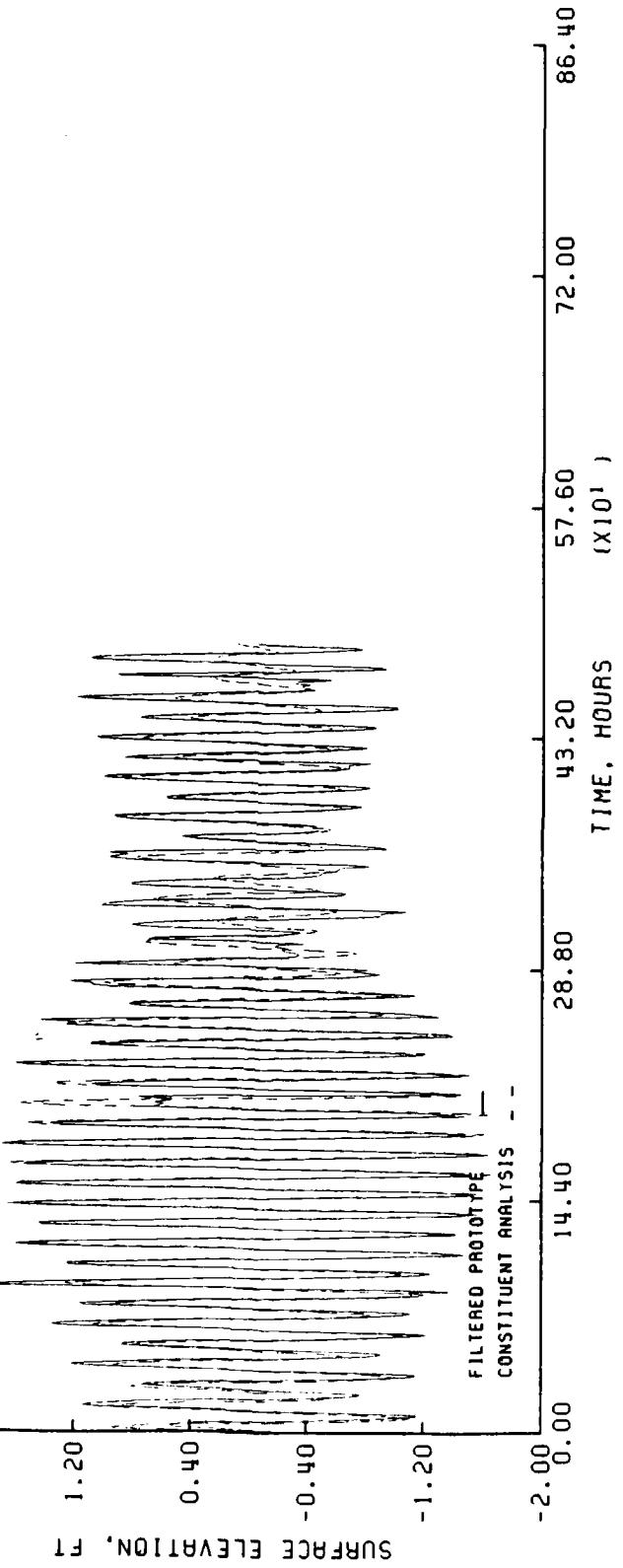
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PONCE DE LEON INLET PROJECT  
TDR-2, STATION P1152. SEPT TO NOV '83



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
TDR-2, STATION P1152, SEPT 10 NOV 83



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
TDR-2, STATION PI154, SEPT 10 NOV 83



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
TOR-2, STATION P1154, SEPT 10 NOV '83

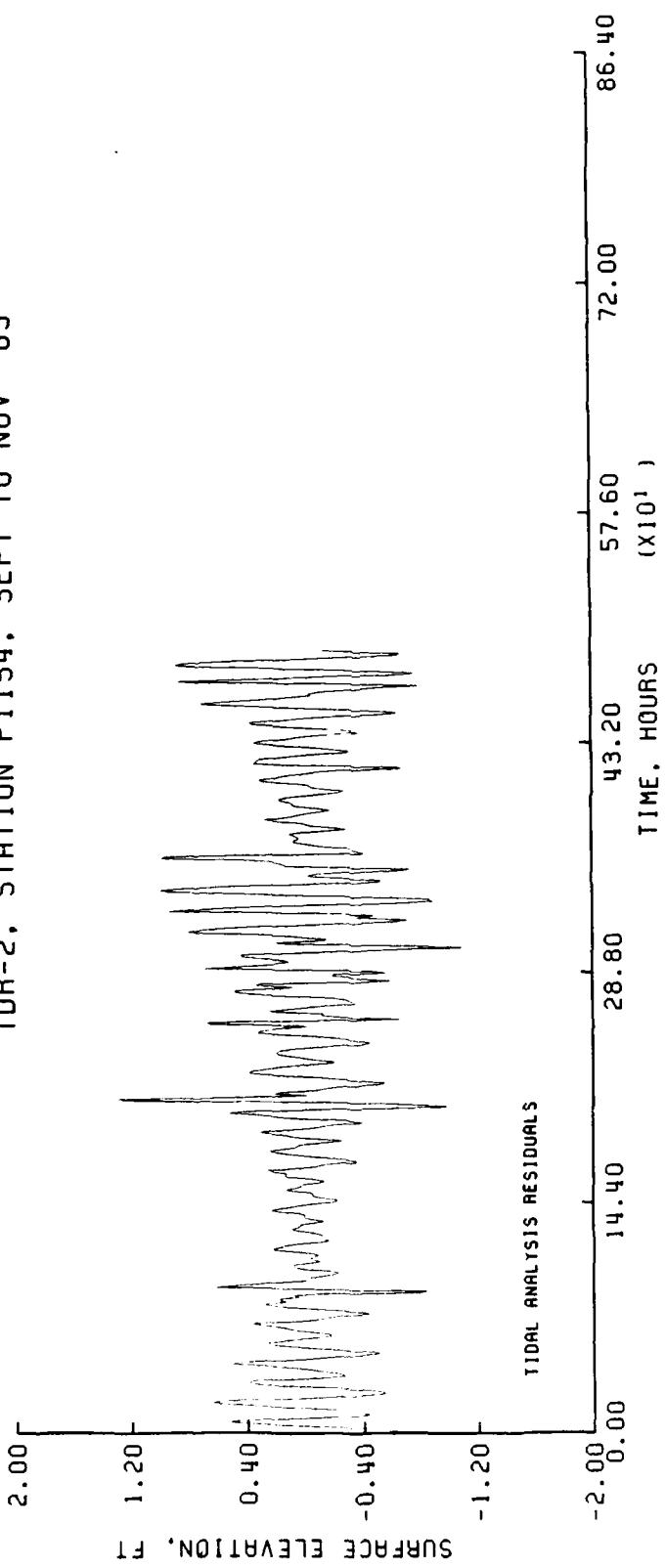
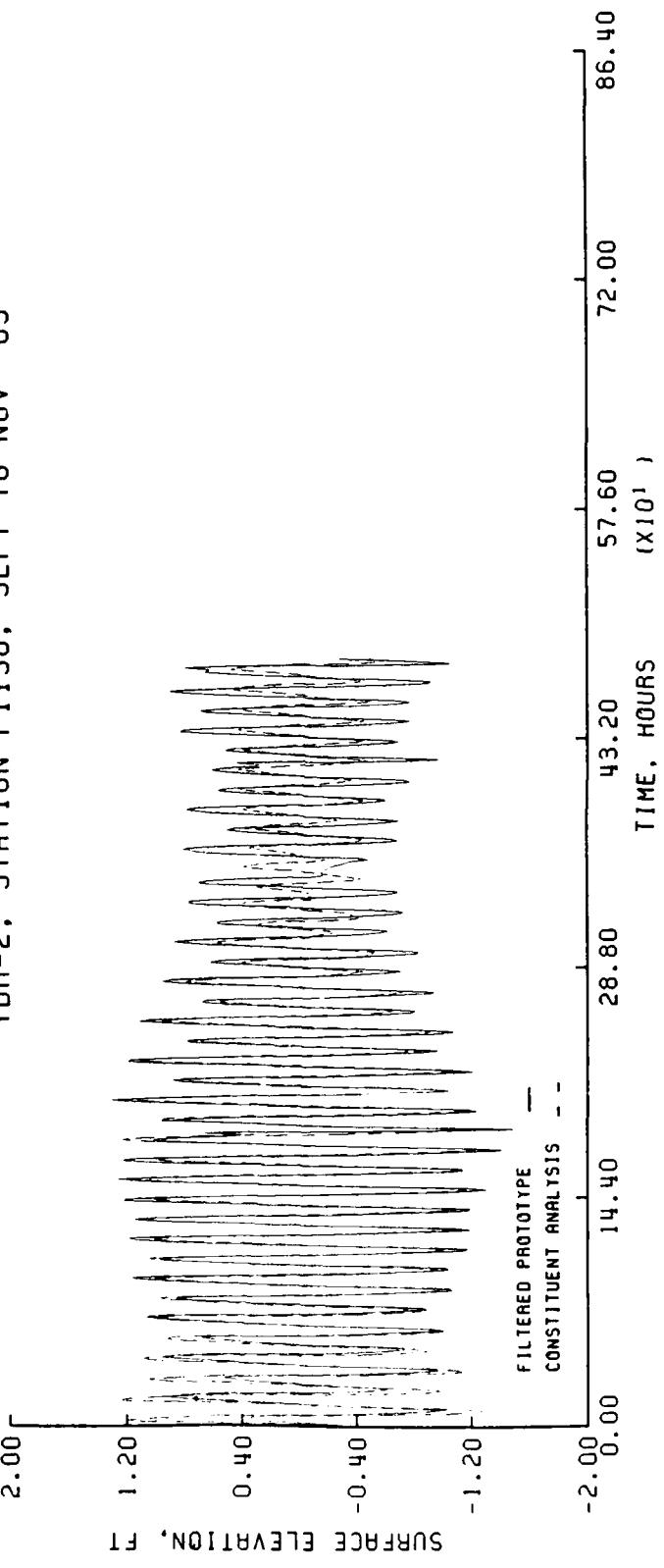
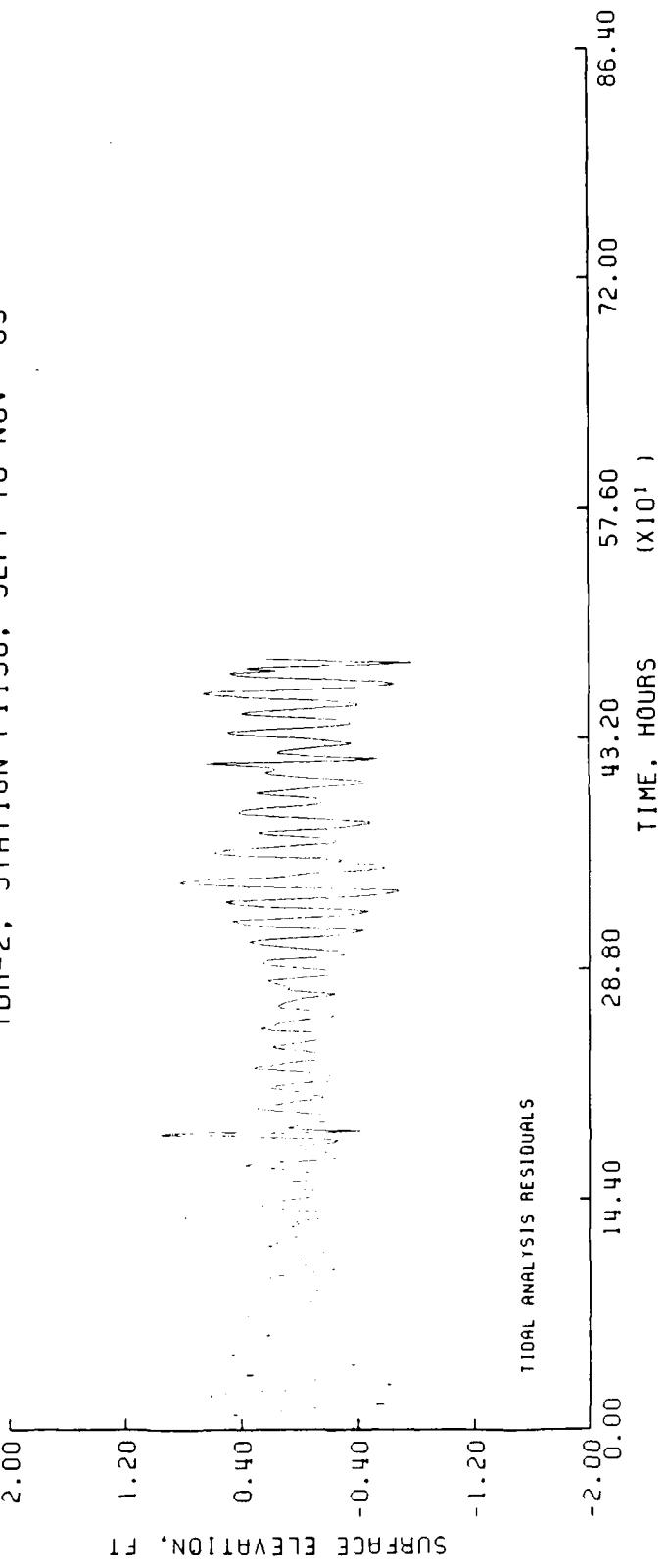


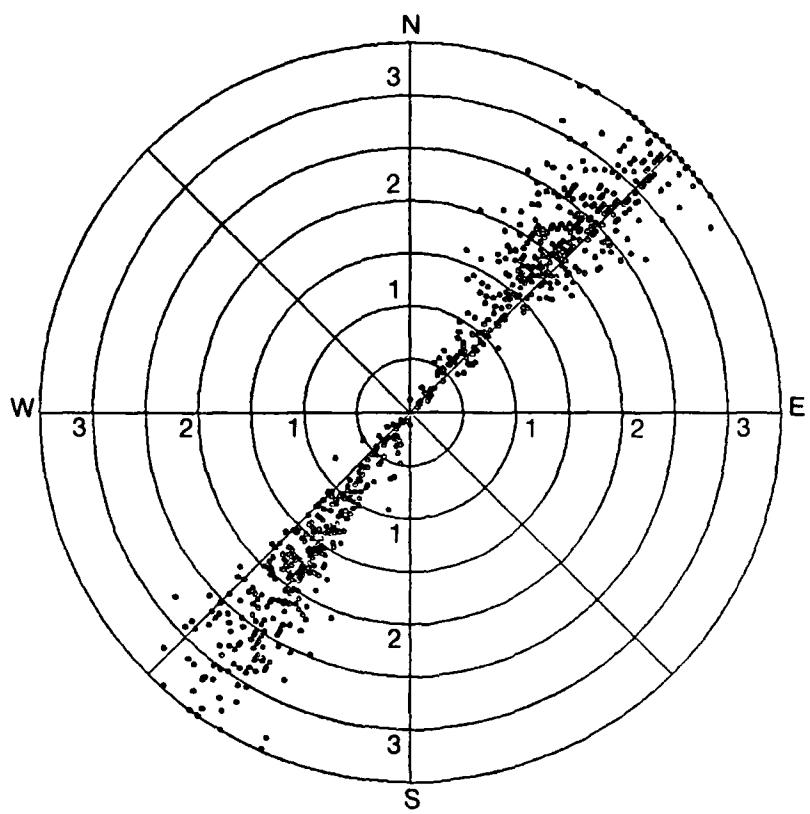
PLATE 17

TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
TDR-2, STATION PI158, SEPT TO NOV  
83



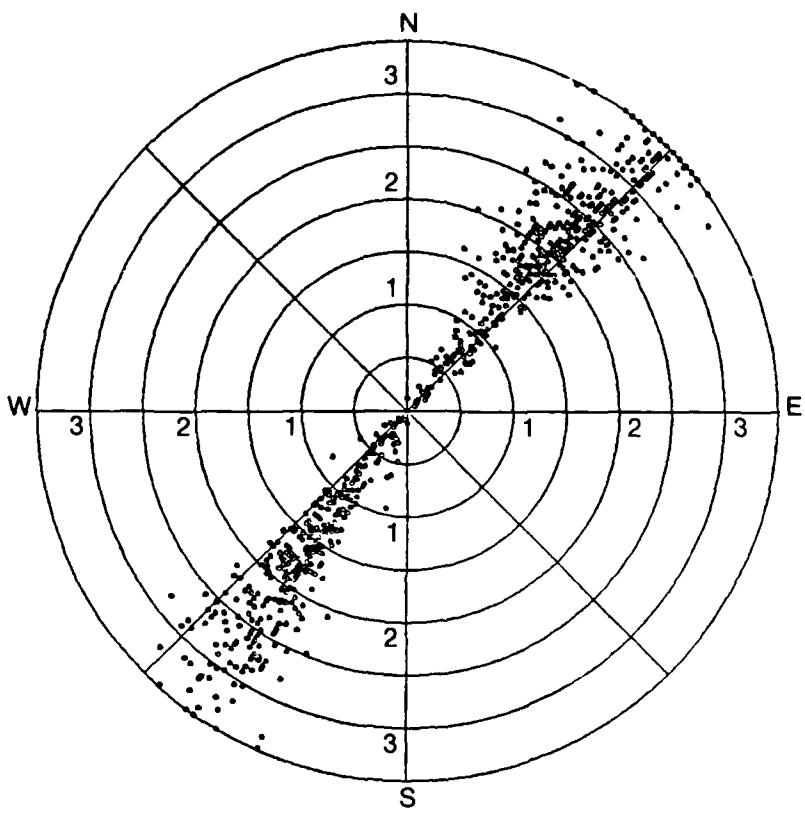
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PONCE DE LEON INLET PROJECT  
TDR-2, STATION PI158, SEPT TO NOV '83





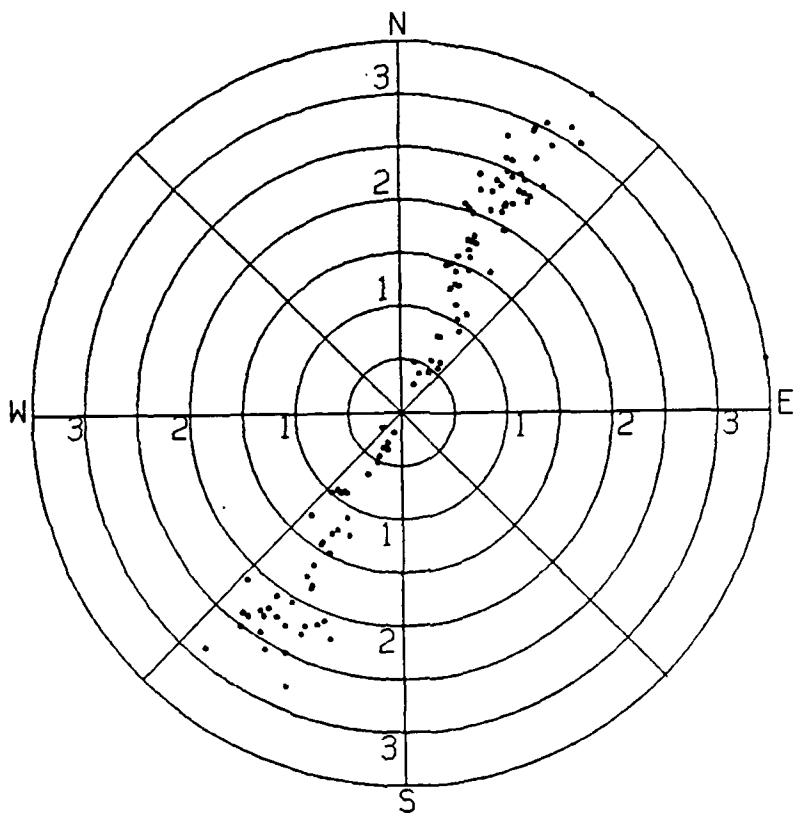
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PONCE DE LEON INLET PROJECT  
STATION PI2AT, SEPT TO NOV '83

SCALE  
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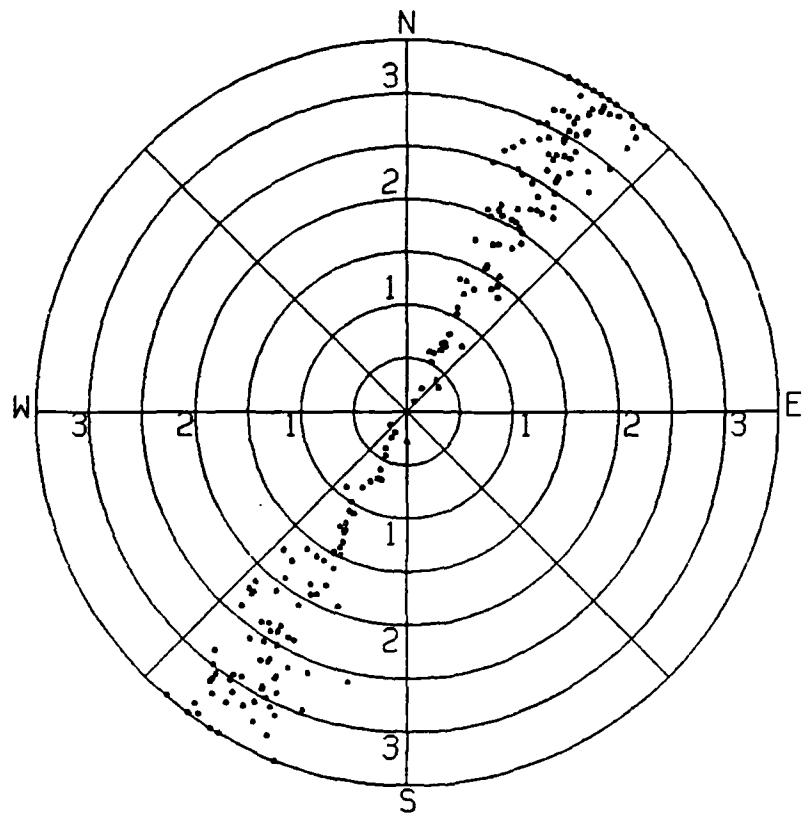
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STATION PI2AT, SEPT TO NOV '83

SCALE  
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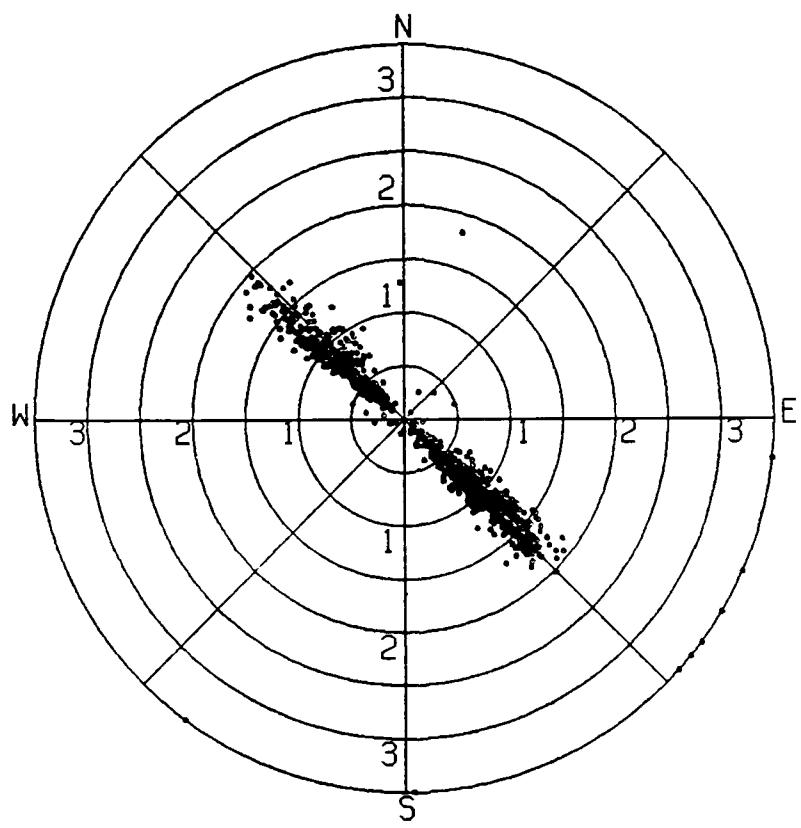
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STATION PI2BB, SEPT TO NOV '83

SCALE  
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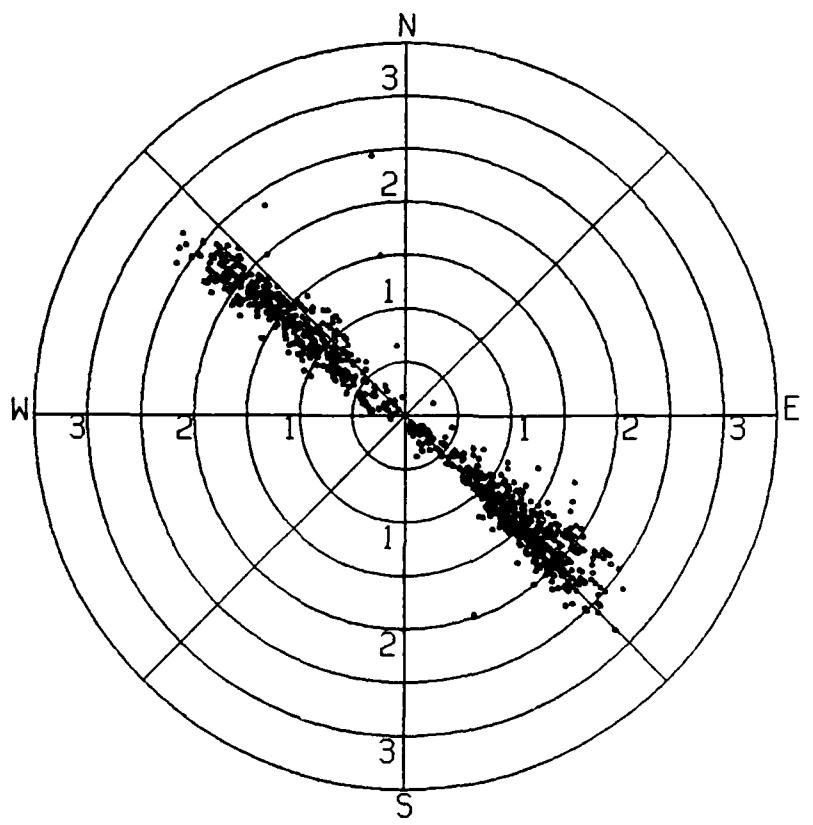
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PONCE DE LEON INLET PROJECT  
STATION PI2BT, SEPT TO NOV '83

SCALE  
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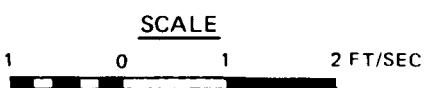


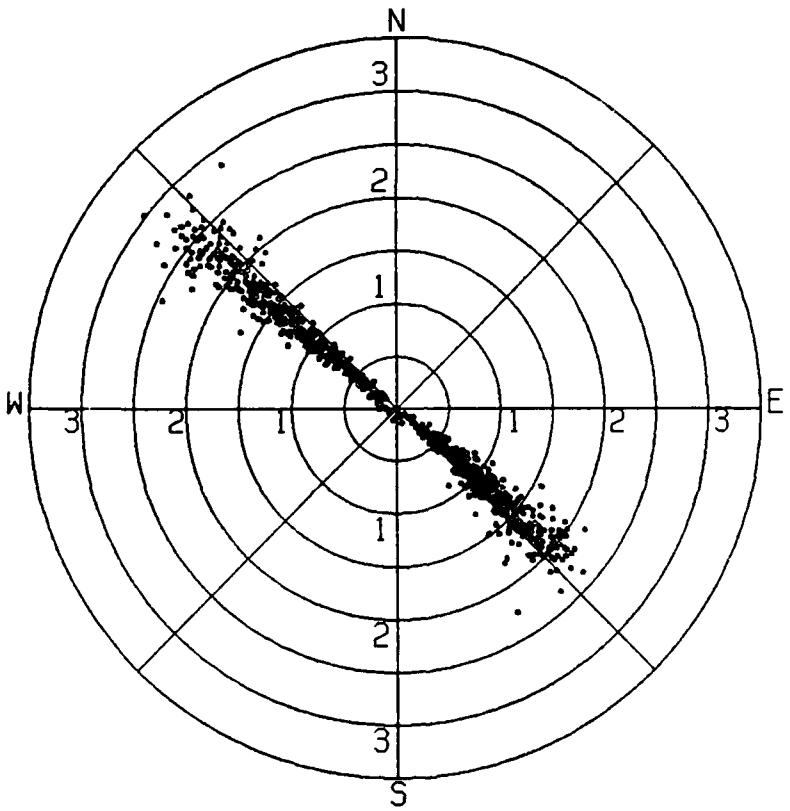
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STATION PI3A, SEPT TO NOV '83

SCALE  
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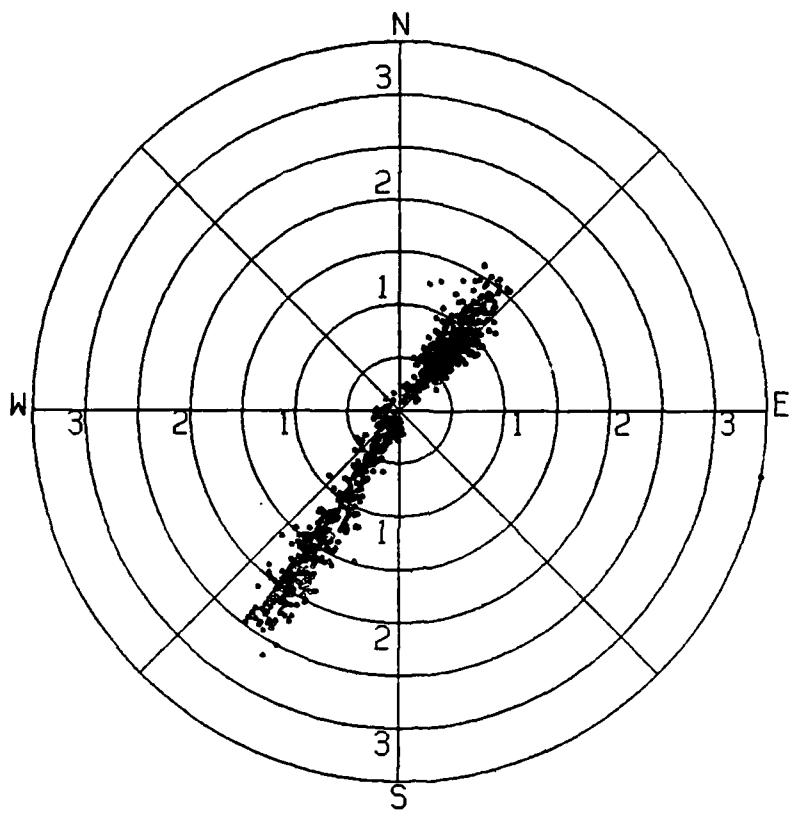
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STATION PI3B, SEPT TO NOV '83





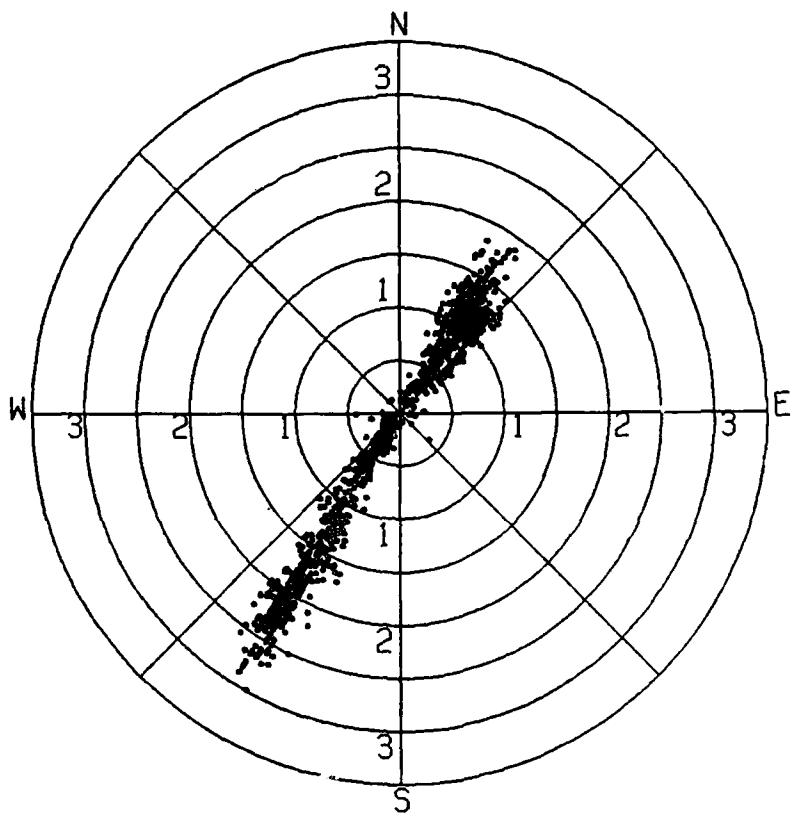
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PONCE DE LEON INLET PROJECT  
STATION PI3C, SEPT TO NOV '83

SCALE  
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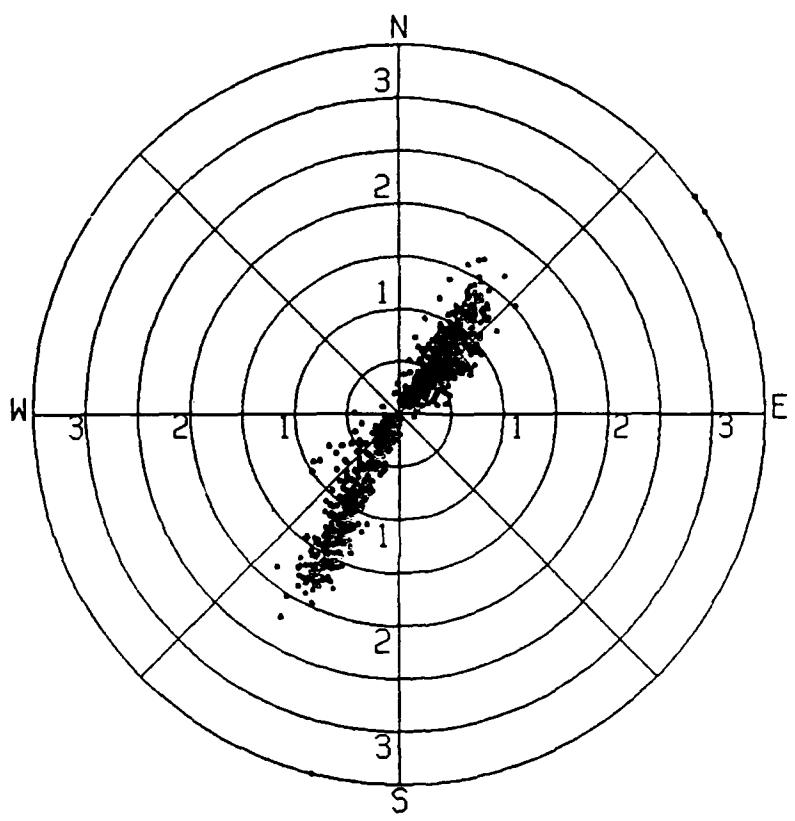
CURRENT VECTOR ROSE  
PONCE DE LEON INLET PROJECT  
STATION PI4AB, SEPT TO NOV '83

SCALE  
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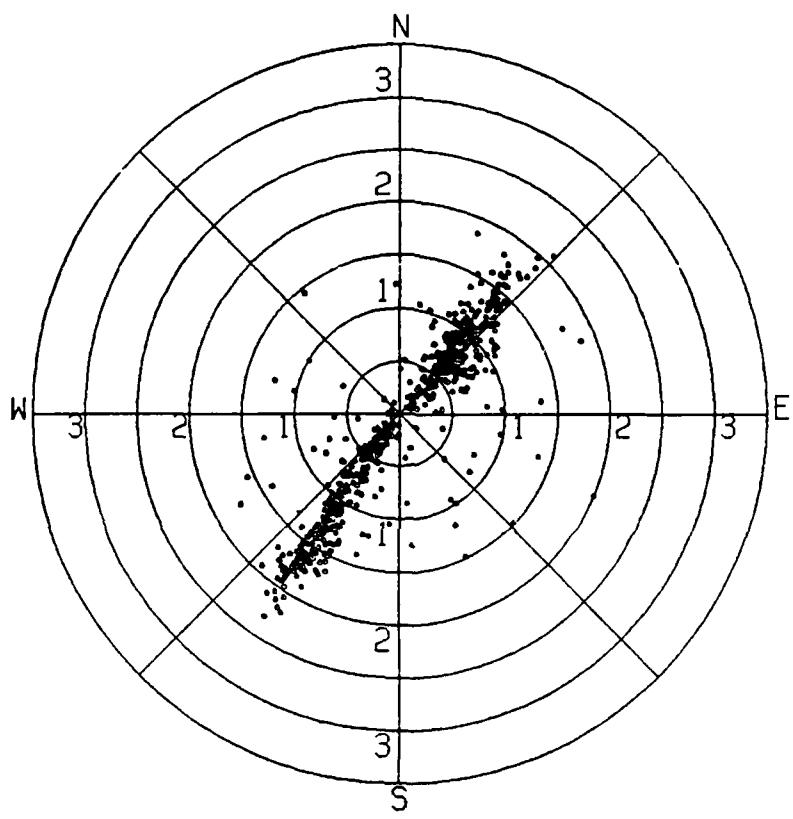
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PONCE DE LEÓN INLET PROJECT  
STATION PI4AT, SEPT TO NOV '83

SCALE  
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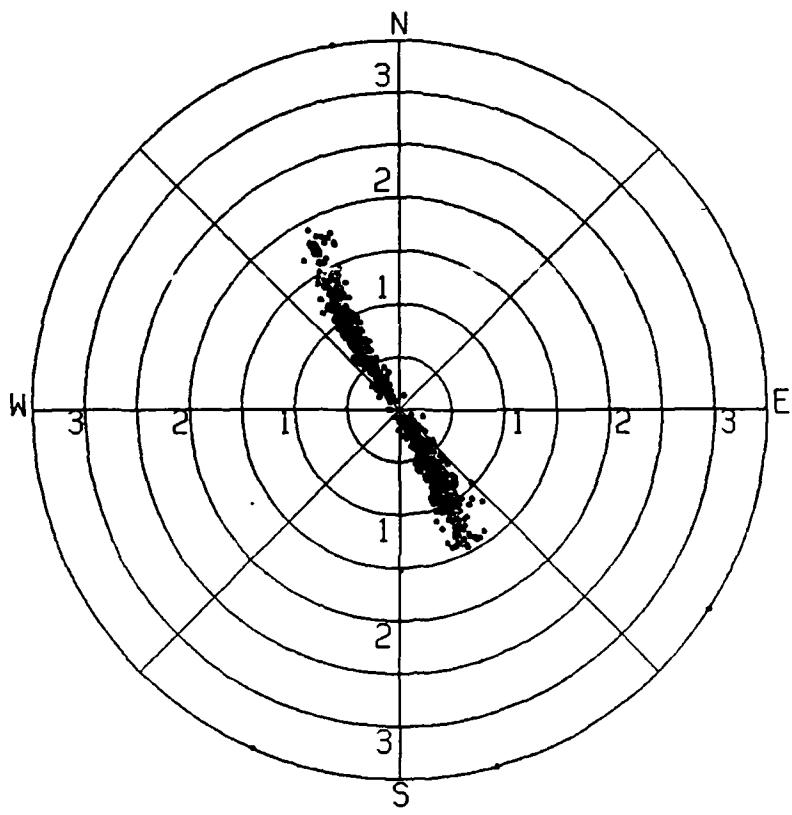
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PONCE DE LEON INLET PROJECT  
STATION PI4BB, SEPT TO NOV '83

SCALE  
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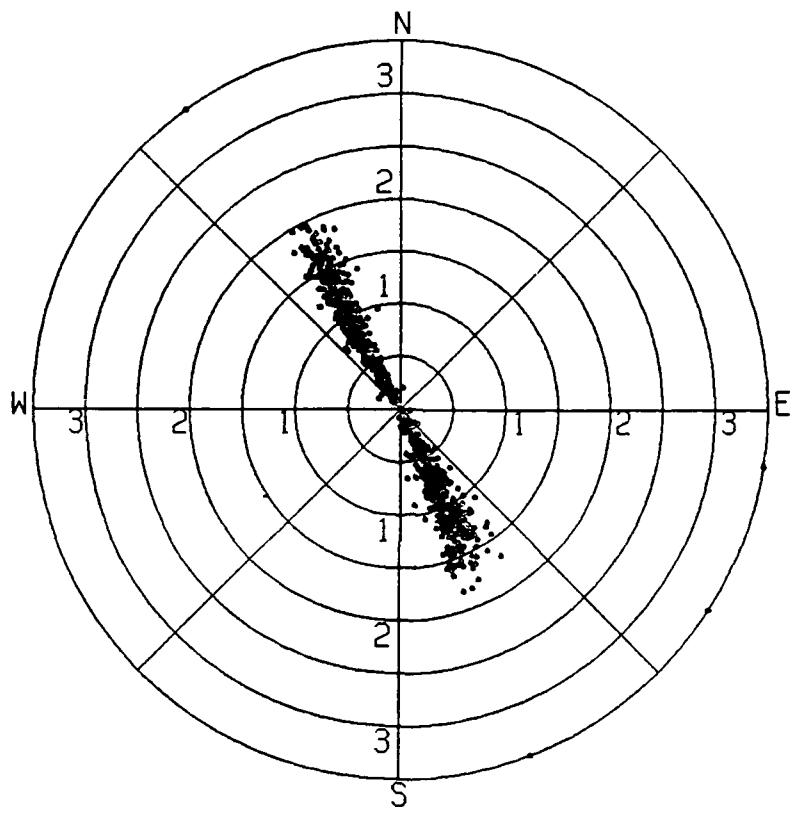
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STATION PI4BT, SEPT 10 NOV '83

SCALE  
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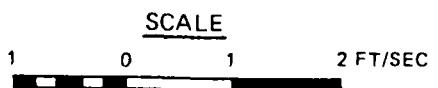


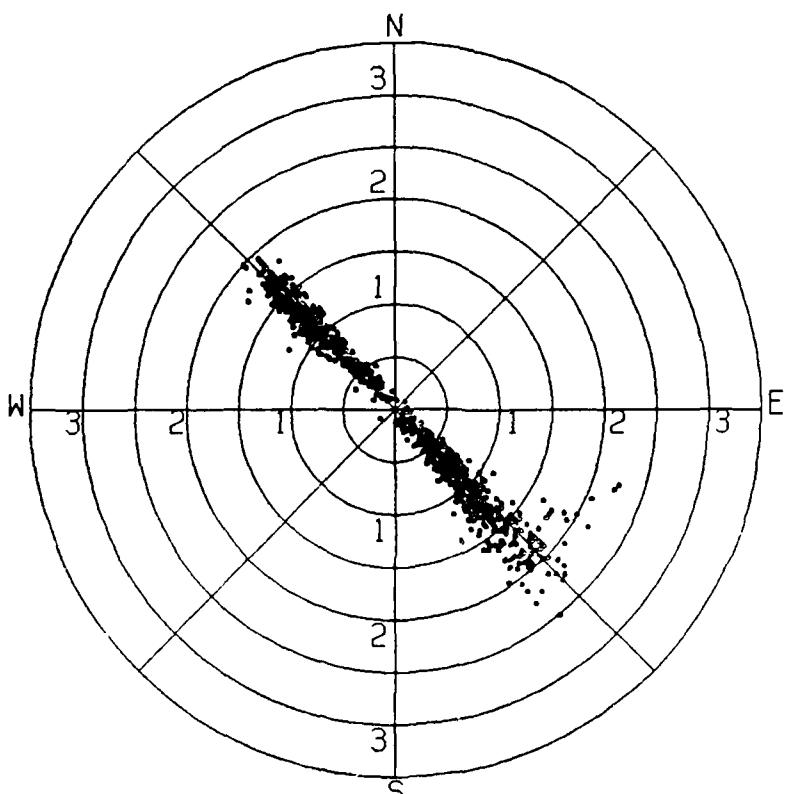
CURRENT VECTOR ROSE  
PONCE DE LEÓN INLET PROJECT  
STATION P15A, SEPT TO NOV '83

SCALE  
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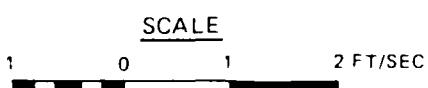


CURRENT VECTOR ROSE  
PONCE DE LEON INLET PROJECT  
STATION PI5B, SEPT TO NOV '83

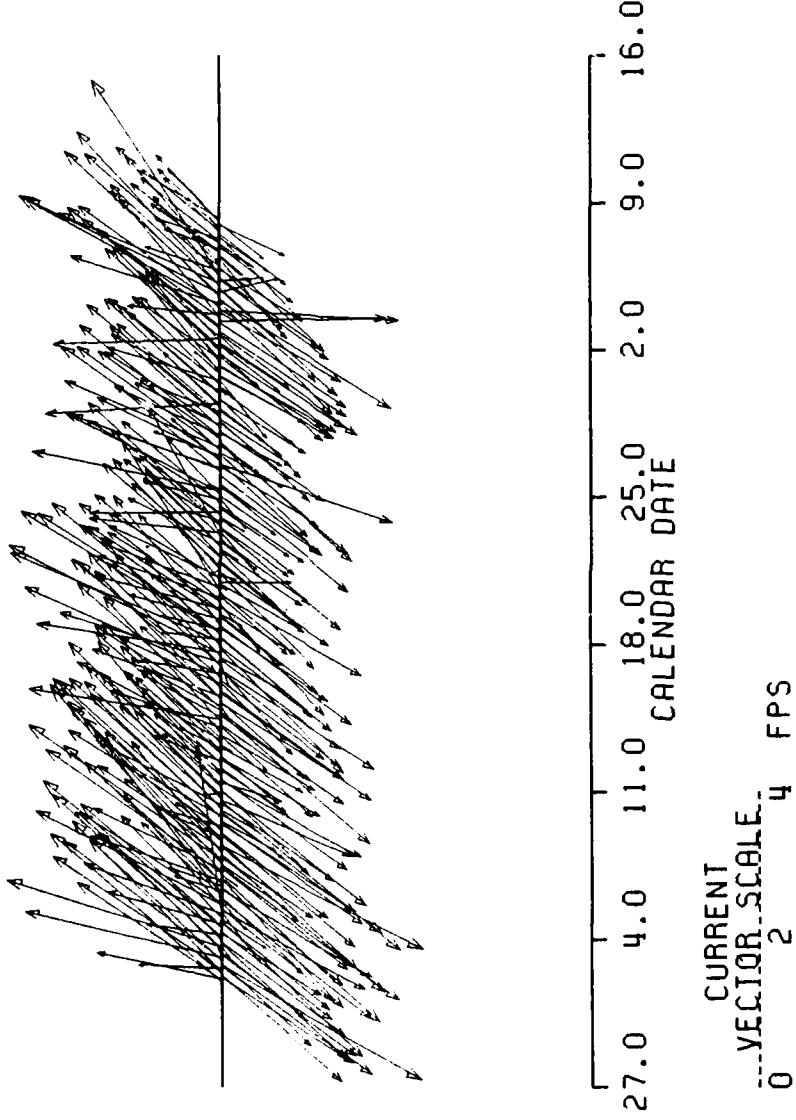




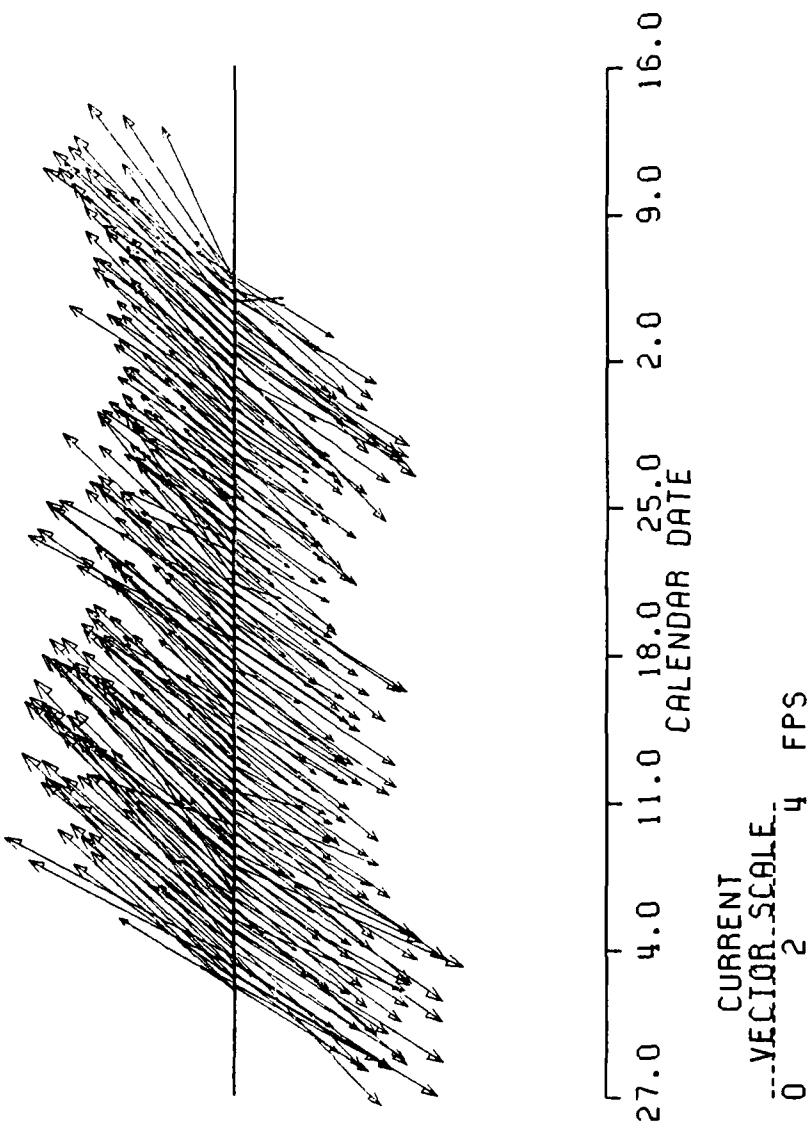
CURRENT VECTOR ROSE  
PONCE DE LEÓN INLET PROJECT  
STATION PI5C, SEPT TO NOV '83



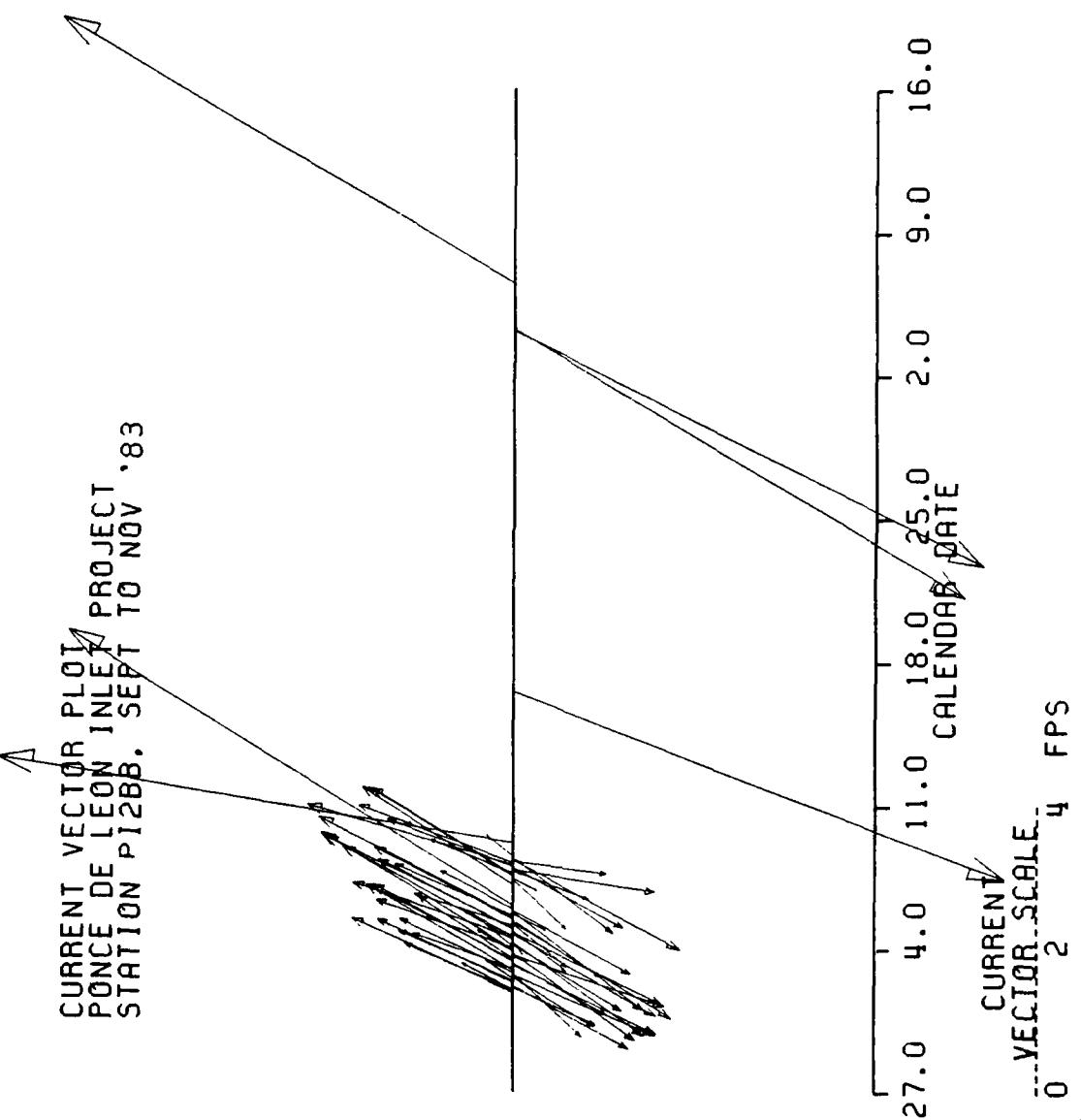
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PONCE DE LEON INLET PROJECT  
STATION P12AB, SEPT TO NOV '83



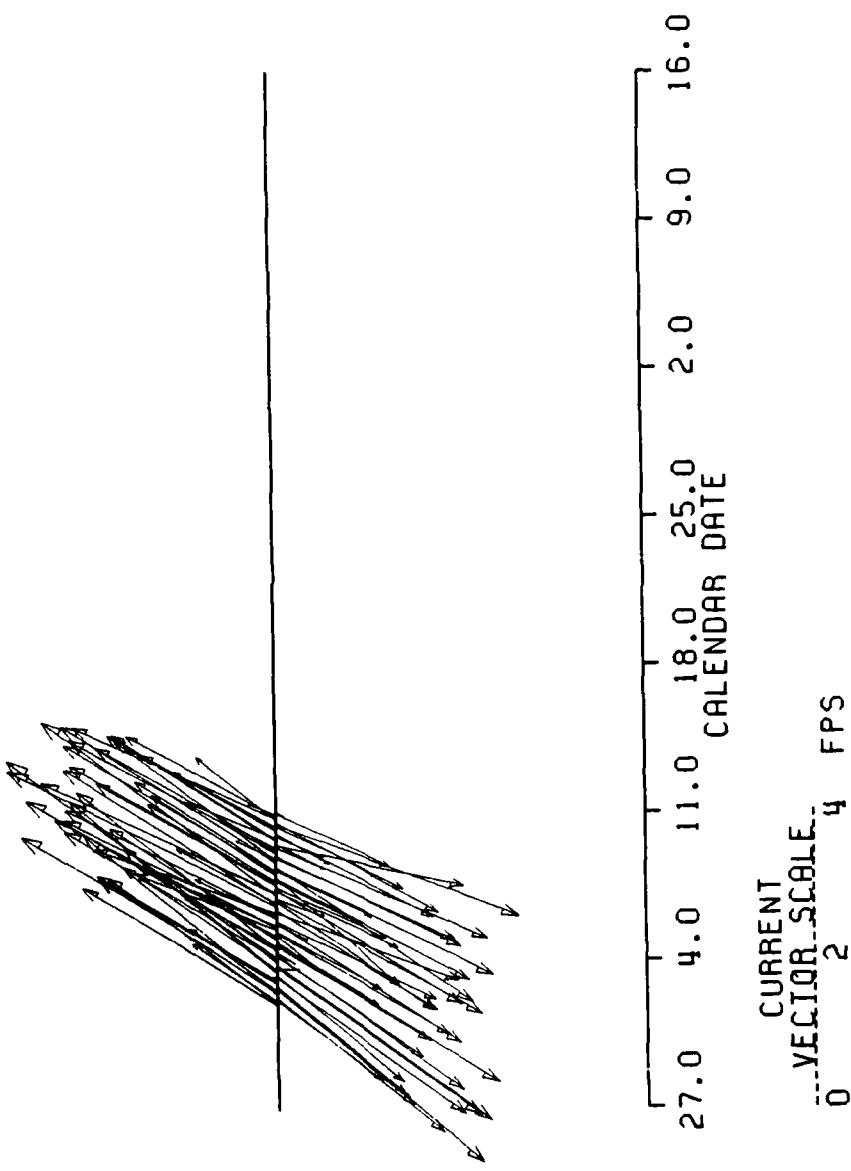
CURRENT VECTOR PLOT  
PONCE DE LEON INLET PROJECT  
STATION P12AT. SEPT 10 NOV '83



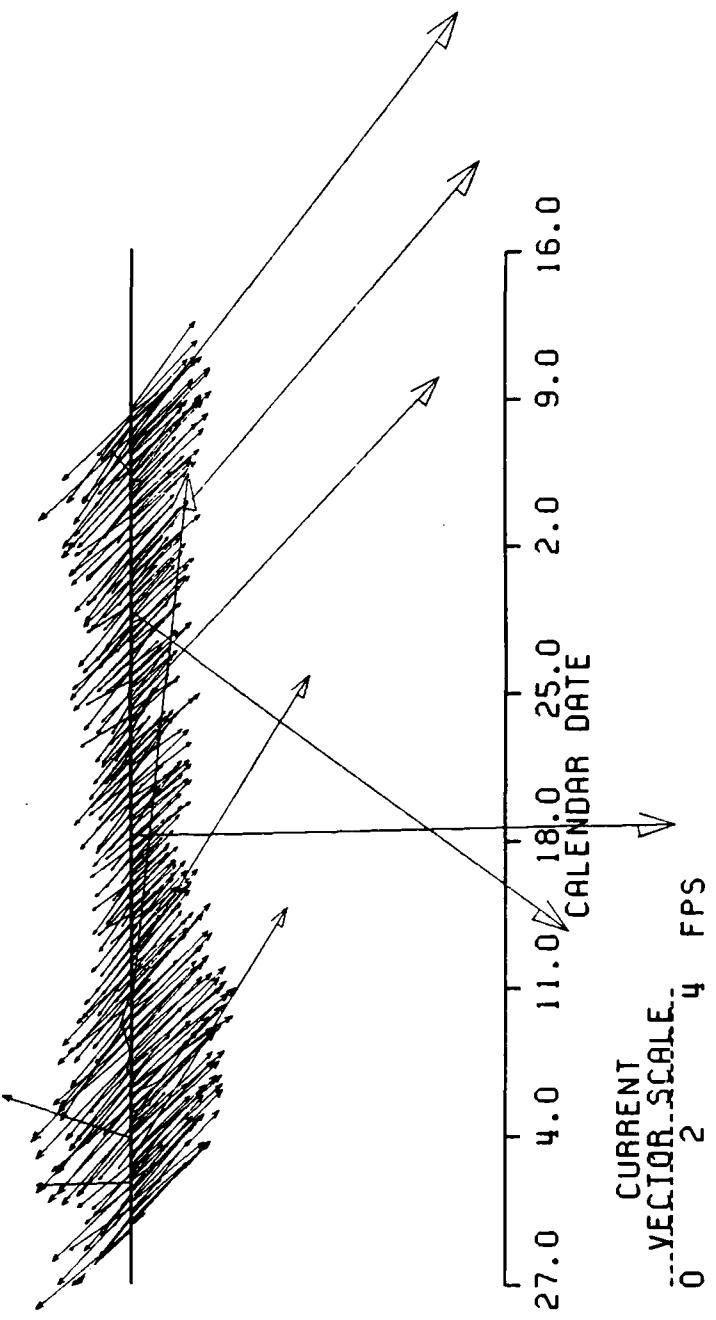
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PONCE DE LEON INLET PROJECT  
STATION PI2BB. SEPT TO NOV '83



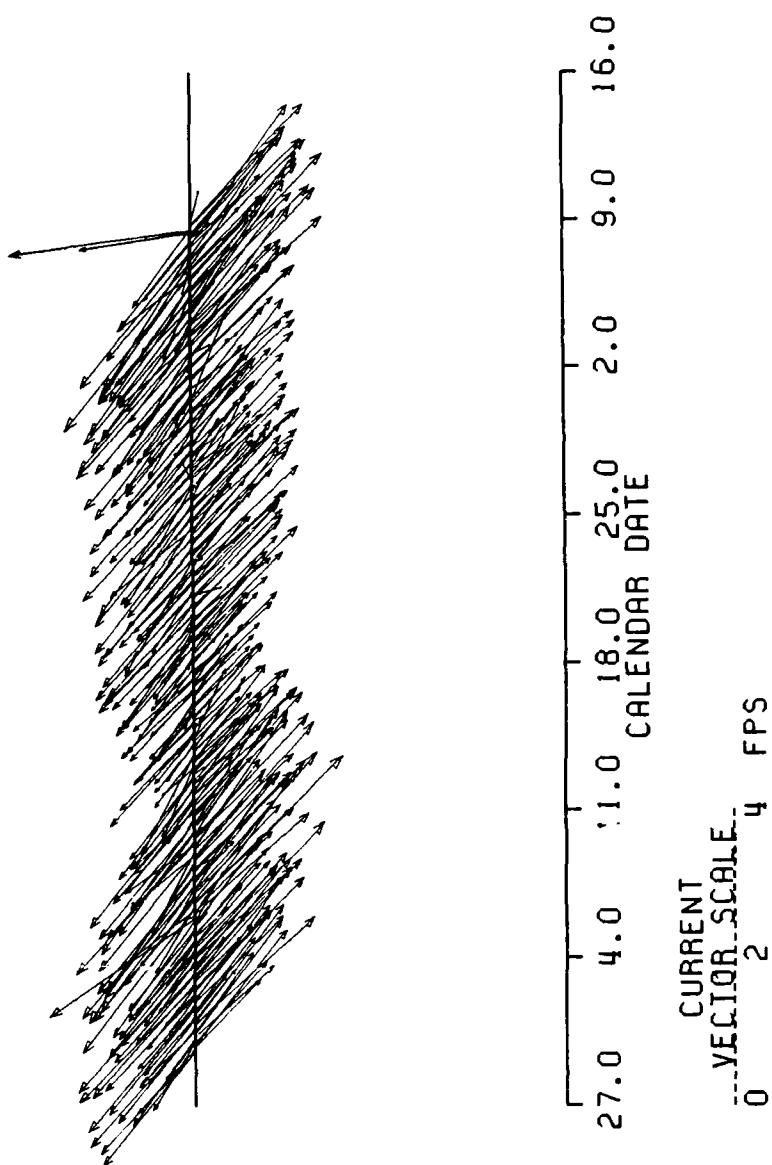
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STATION P12BT. SEPT TO NOV '83



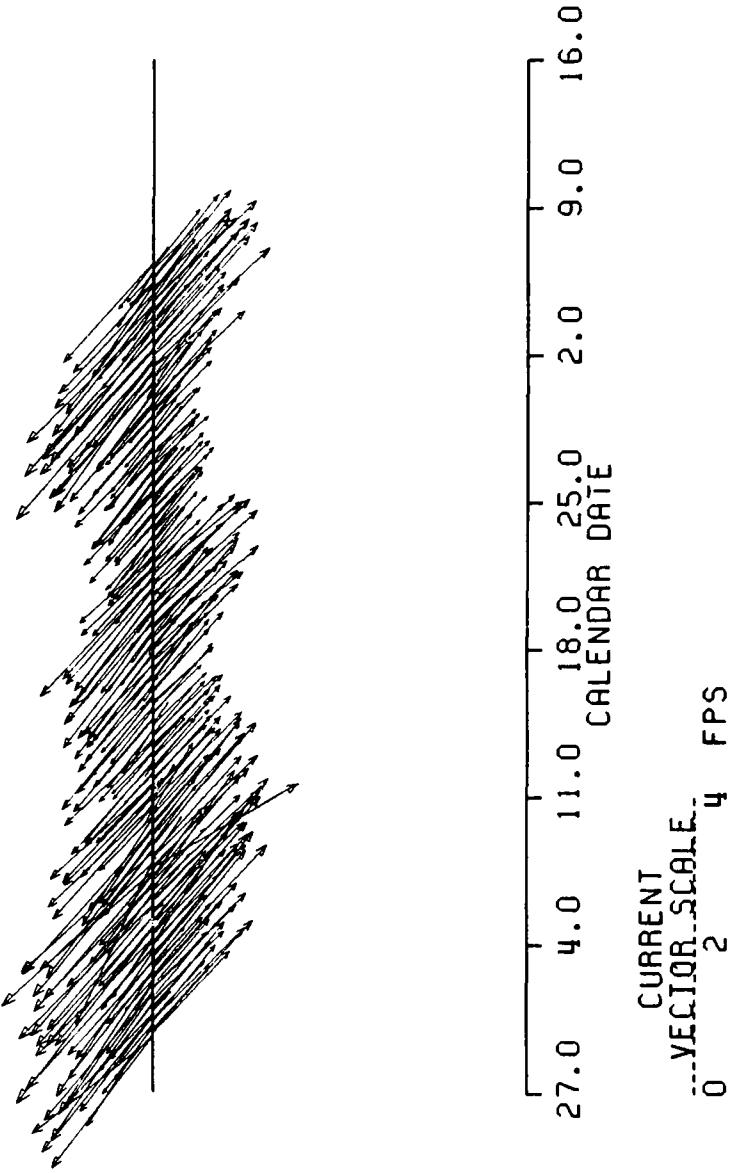
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PONCE DE LEON INLET PROJECT  
STATION P13A. SEPT 10 NOV '83



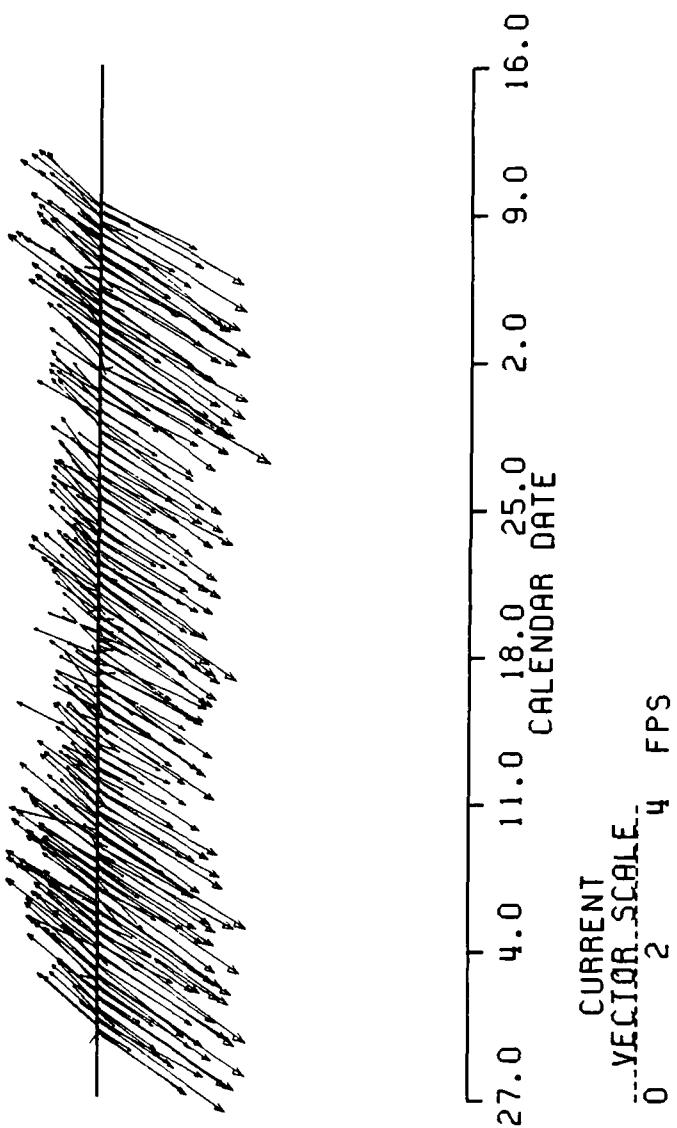
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PONCE DE LEON INLET PROJECT  
STATION P13B, SEPT TO NOV '83



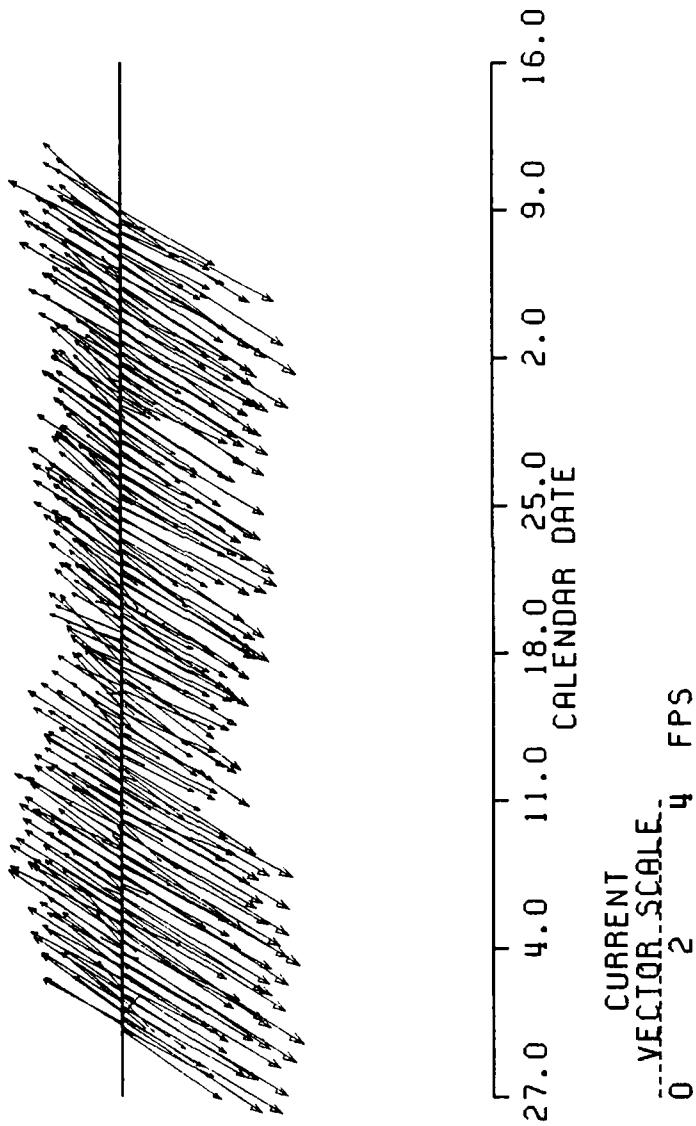
CURRENT VECTOR PLOT  
PONCE DE LEON INLET PROJECT  
STATION P13C. SEPT TO NOV '83



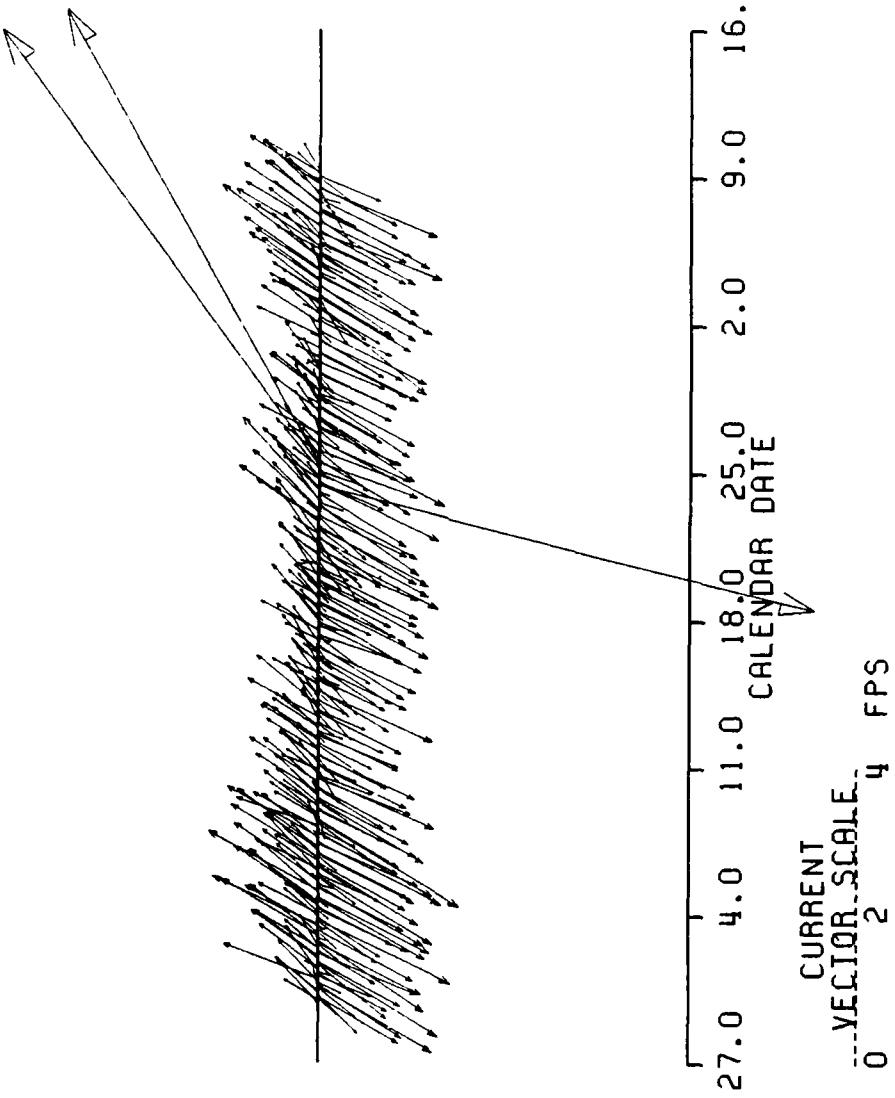
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STATION PI4QAB, SEPT 10 NOV '83



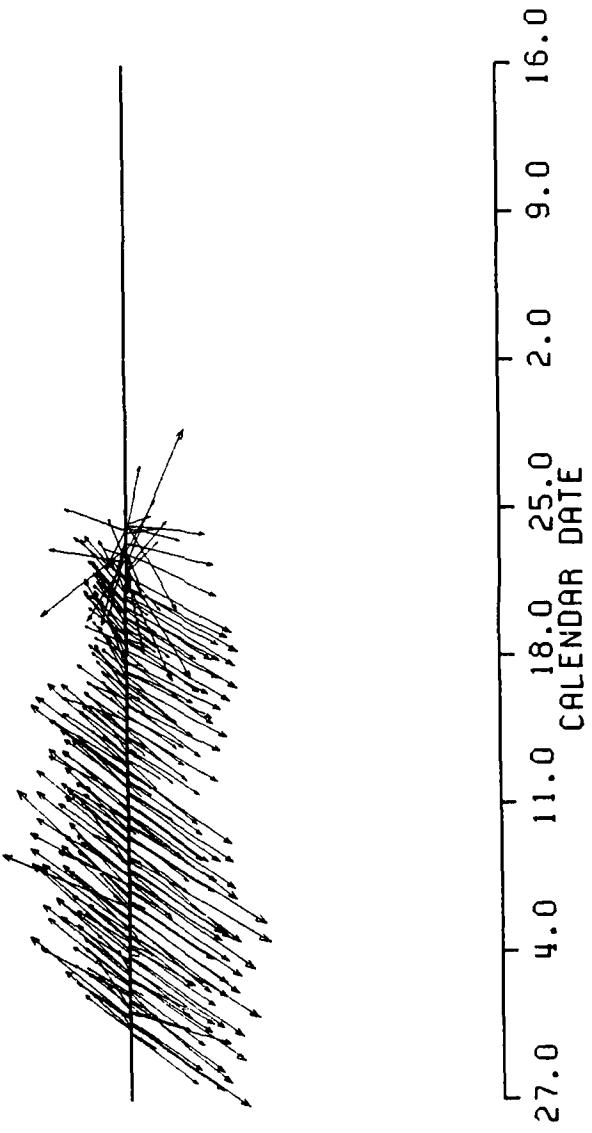
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PONCE DE LEON INLET PROJECT  
STATION PI4AT. SEPT TO NOV '83



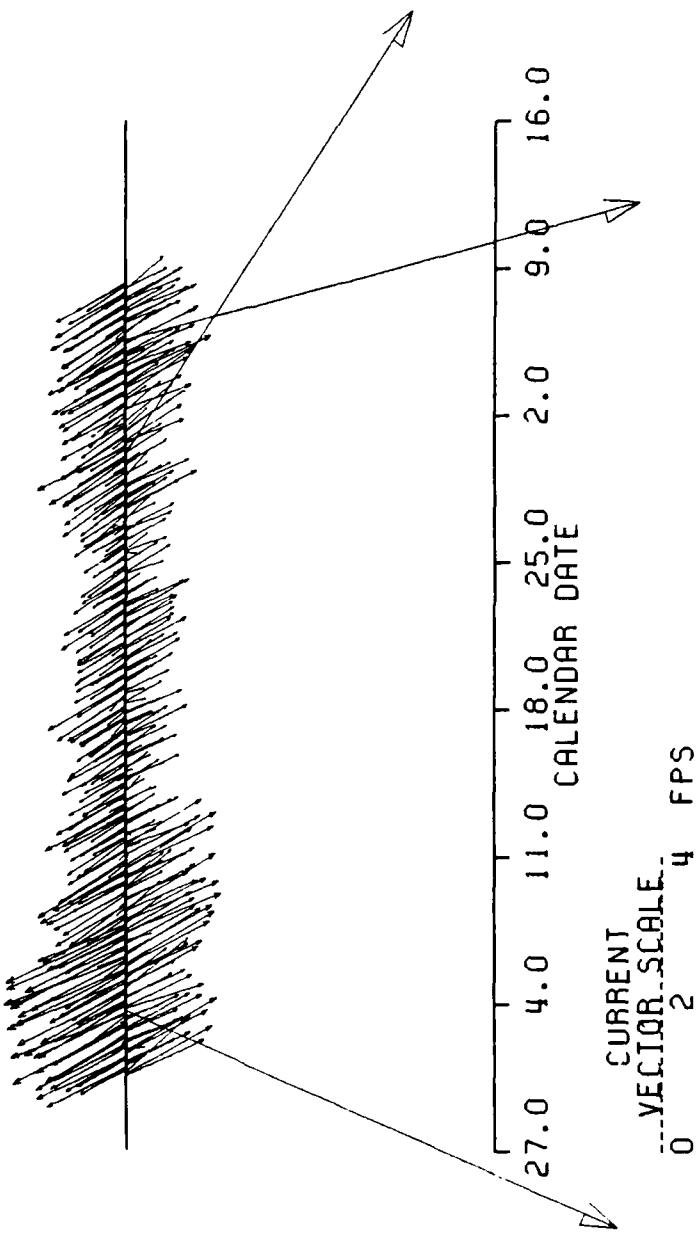
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STATION PI4BB, SEPT TO NOV '83



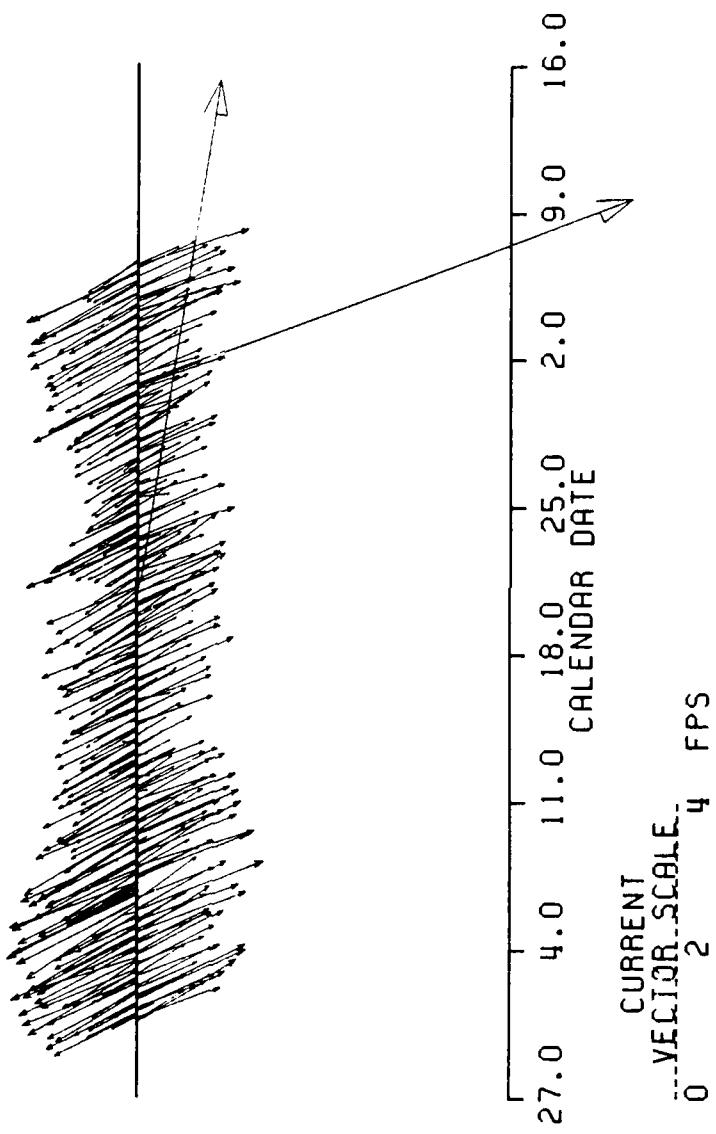
CURRENT VECTOR PLOT  
PONCE DE LEON INLET PROJECT  
STATION PI4BT. SEPT TO NOV '83



CURRENT VECTOR PLOT  
PONCE DE LEON INLET PROJECT  
STATION P15A. SEPT TO NOV. 83



CURRENT VECTOR PLOT  
PONCE DE LEON INLET PROJECT  
STATION P15B, SEPT 10 NOV 83



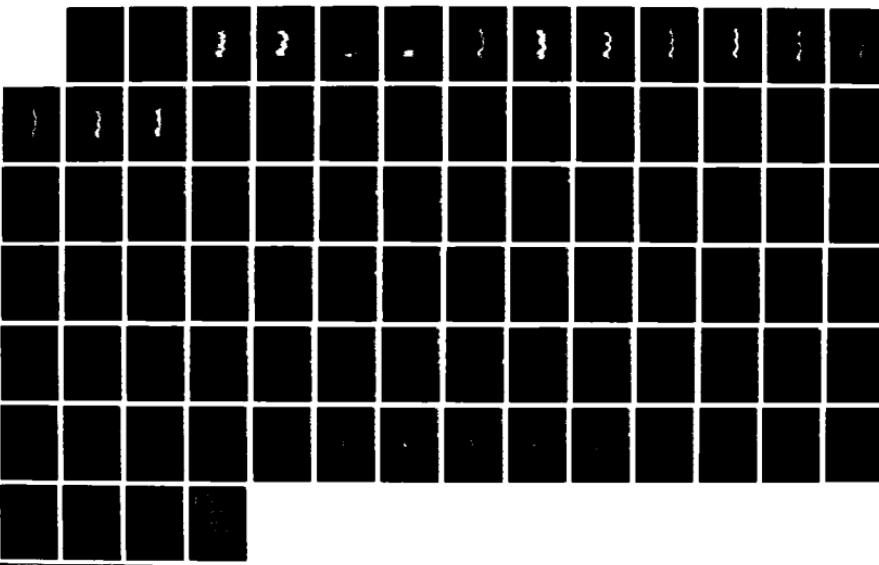
AD-A193 872 TIDAL ELEVATIONS AND CURRENTS AT PONCE DE LEON INLET  
FLORIDA(C) COASTAL ENGINEERING RESEARCH CENTER  
VICKSBURG MS J M HENSLEY ET AL. MAY 88 CERC-MP-88-8

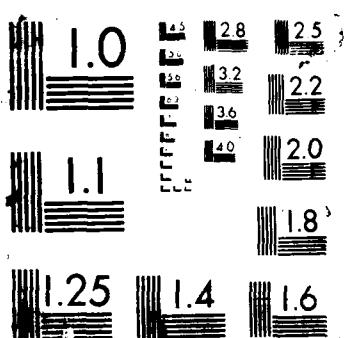
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2/2

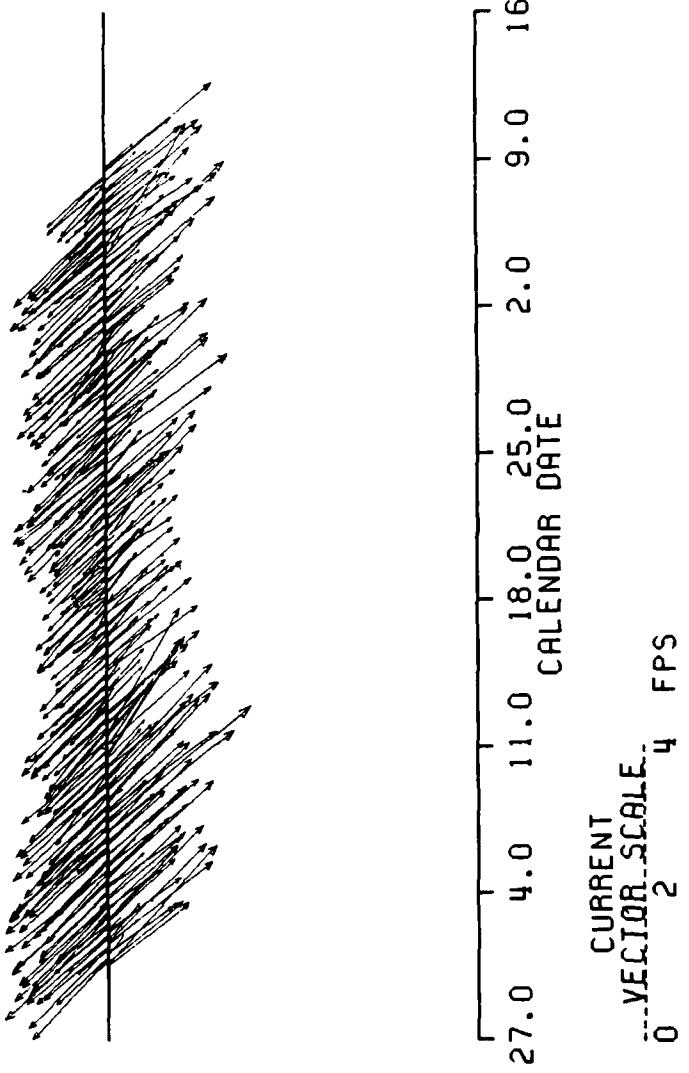
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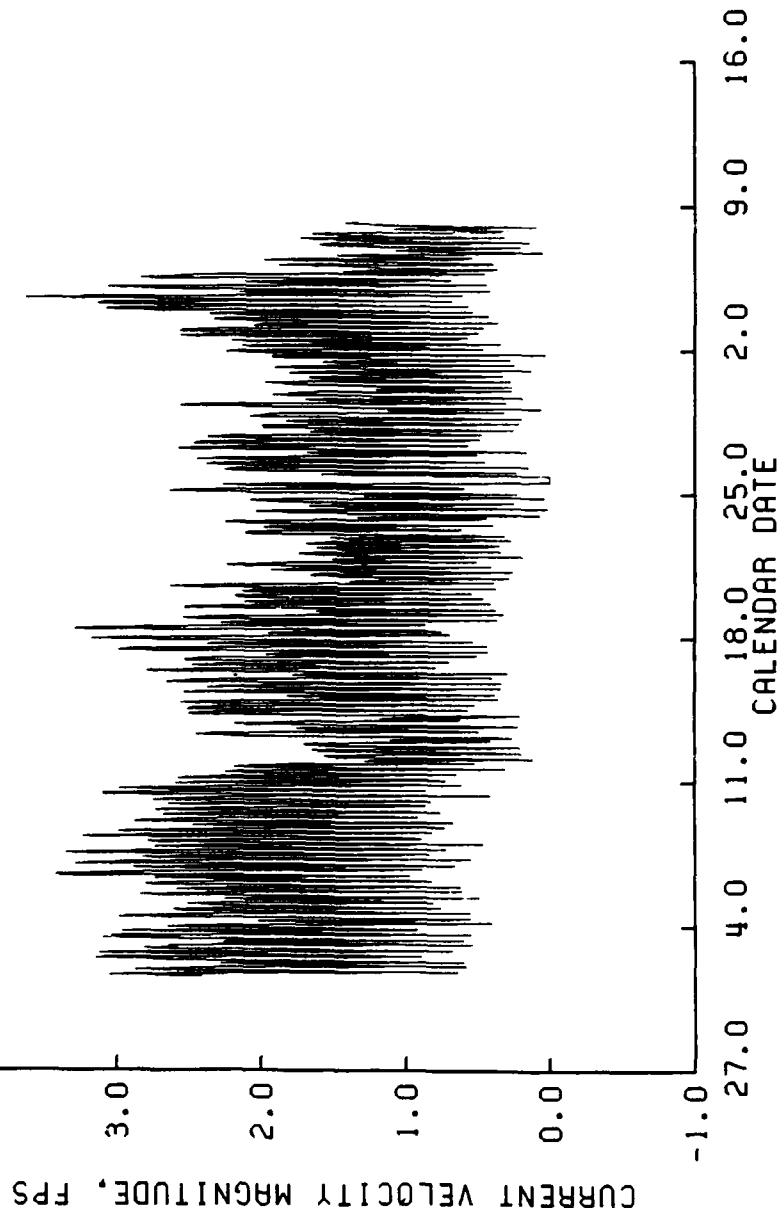




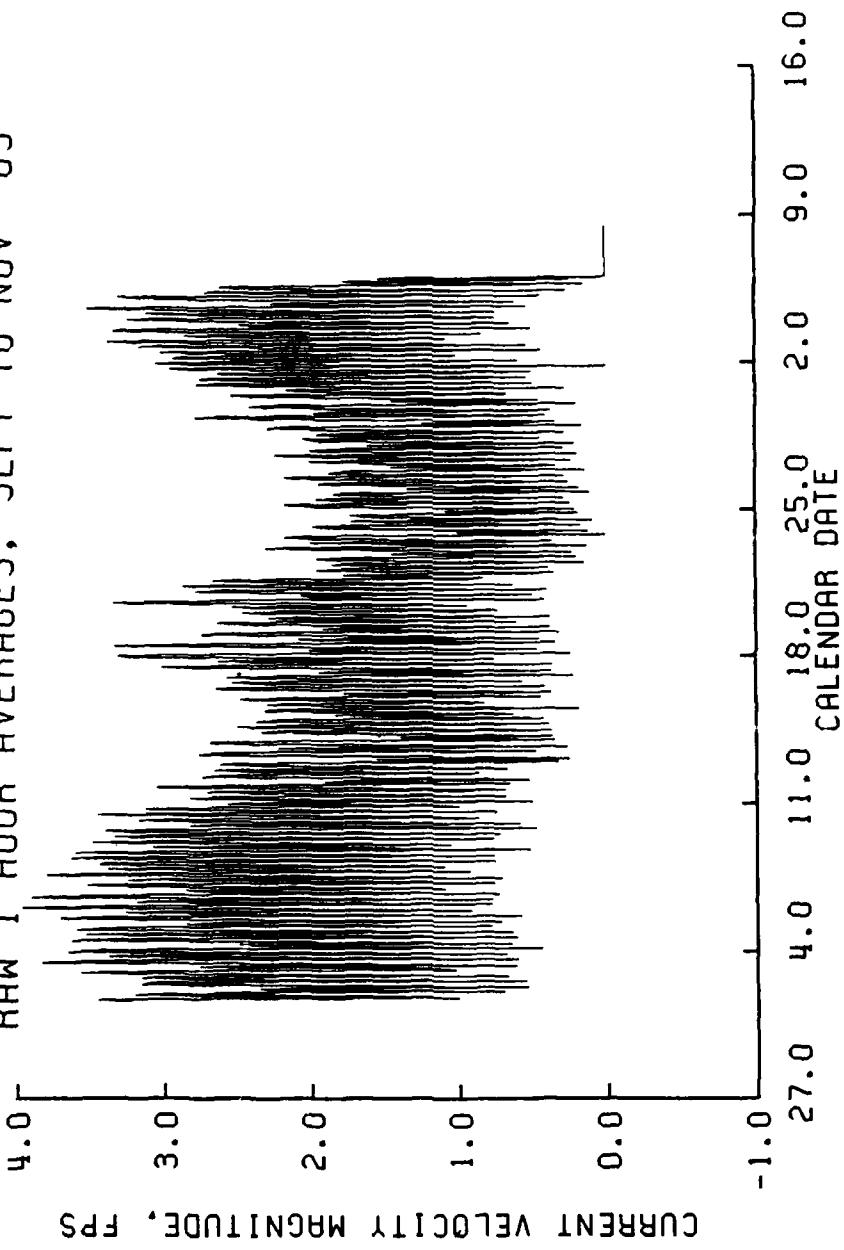
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PONCE DE LEON INLET PROJECT  
STATION P15C. SEPT TO NOV '83



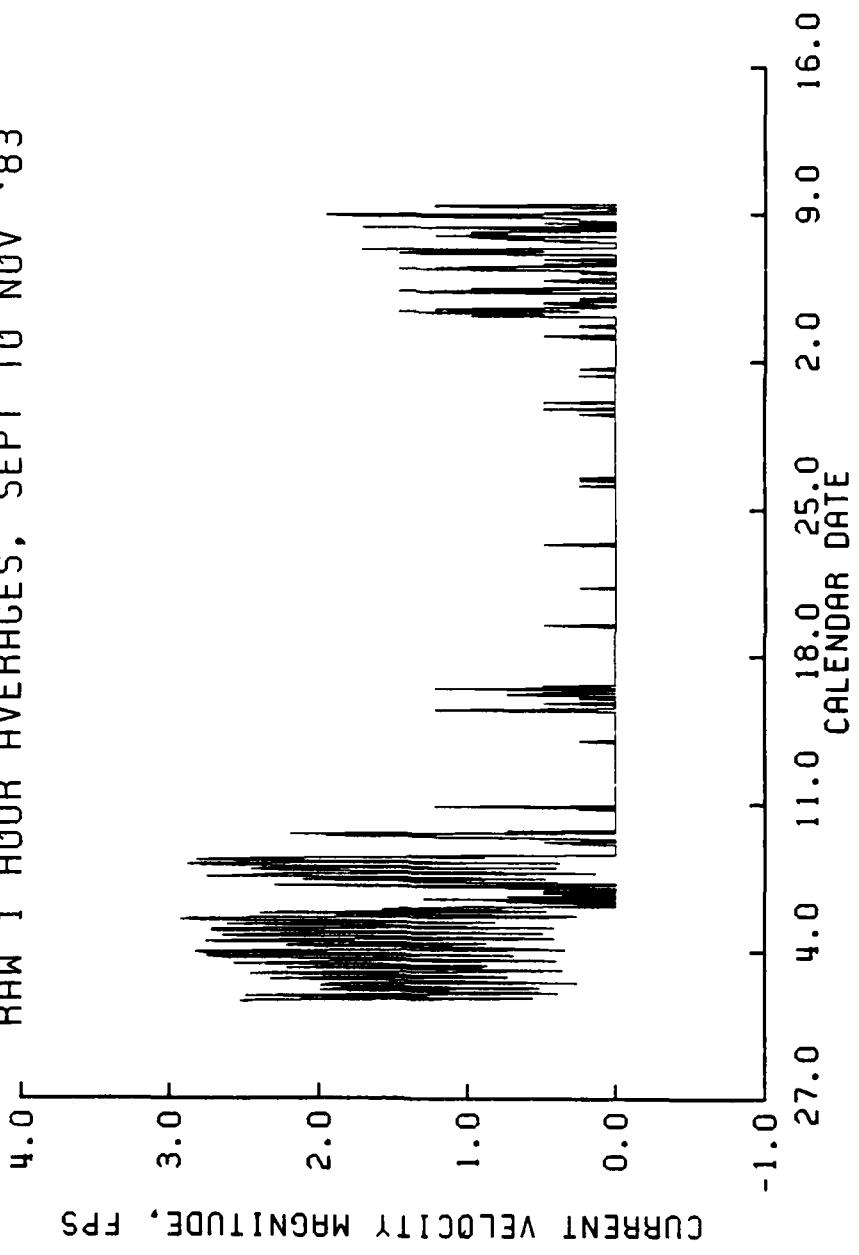
PONCE DE LEON INLET PROJECT  
ENDEC 174, STATION P12AB  
RAW 1 HOUR AVERAGES, SEPT 10 NOV '83



PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P12AT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P12BB  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PI2BT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83

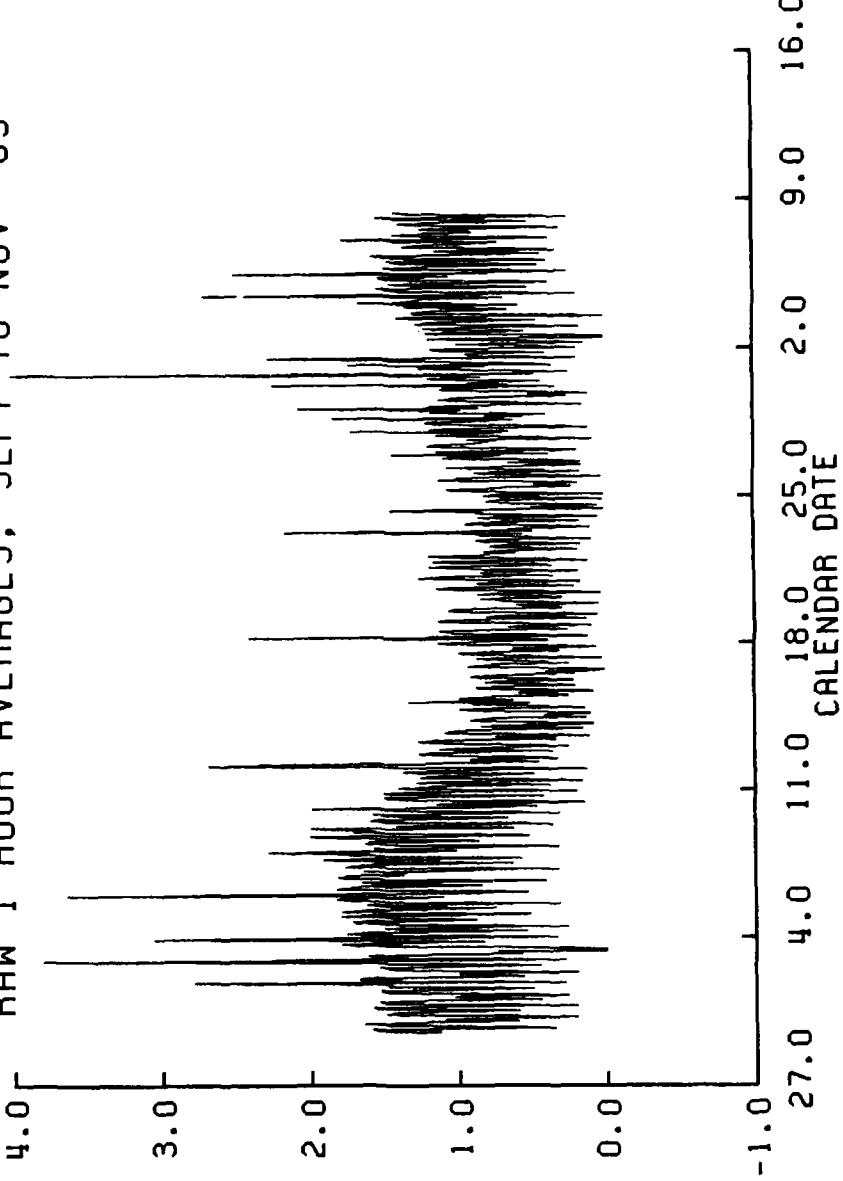
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2.0  
1.0  
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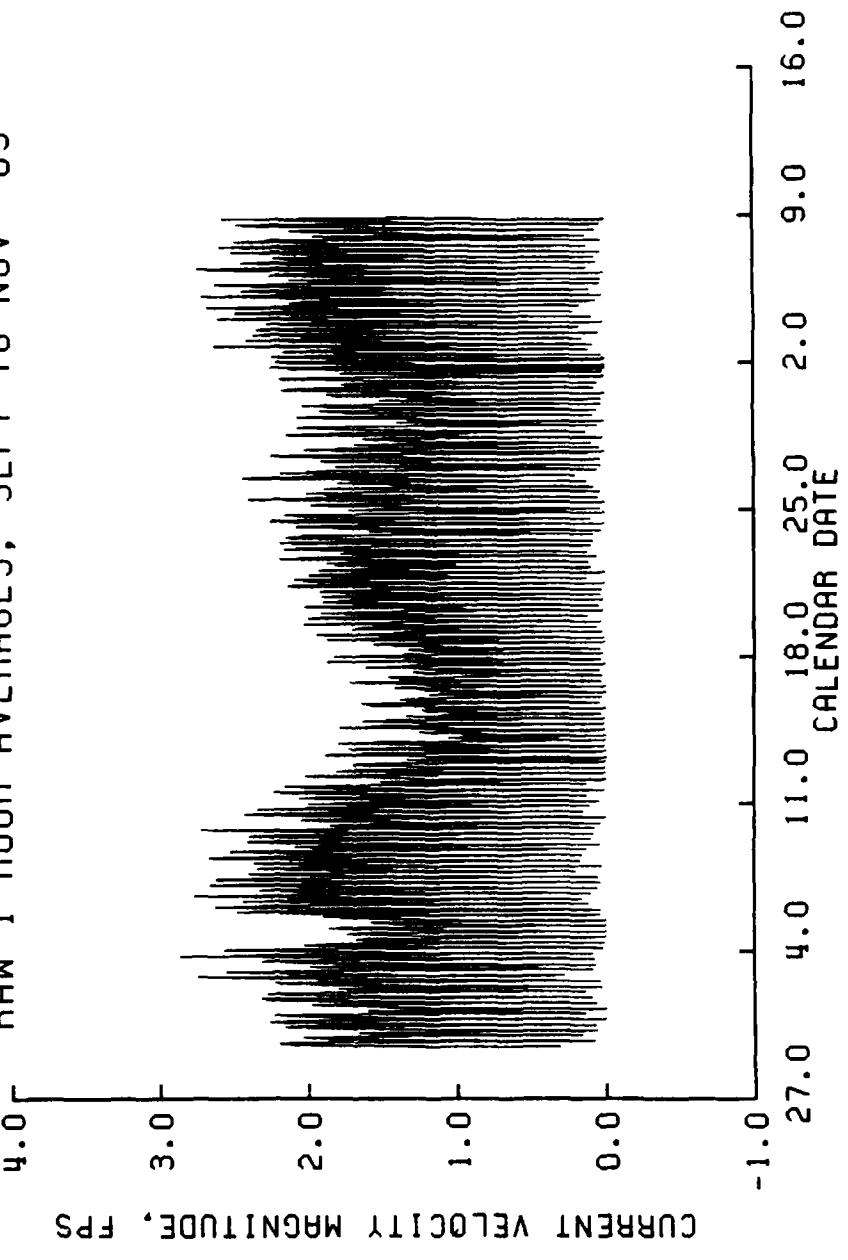
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CALENDAR DATE

PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P13A  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83

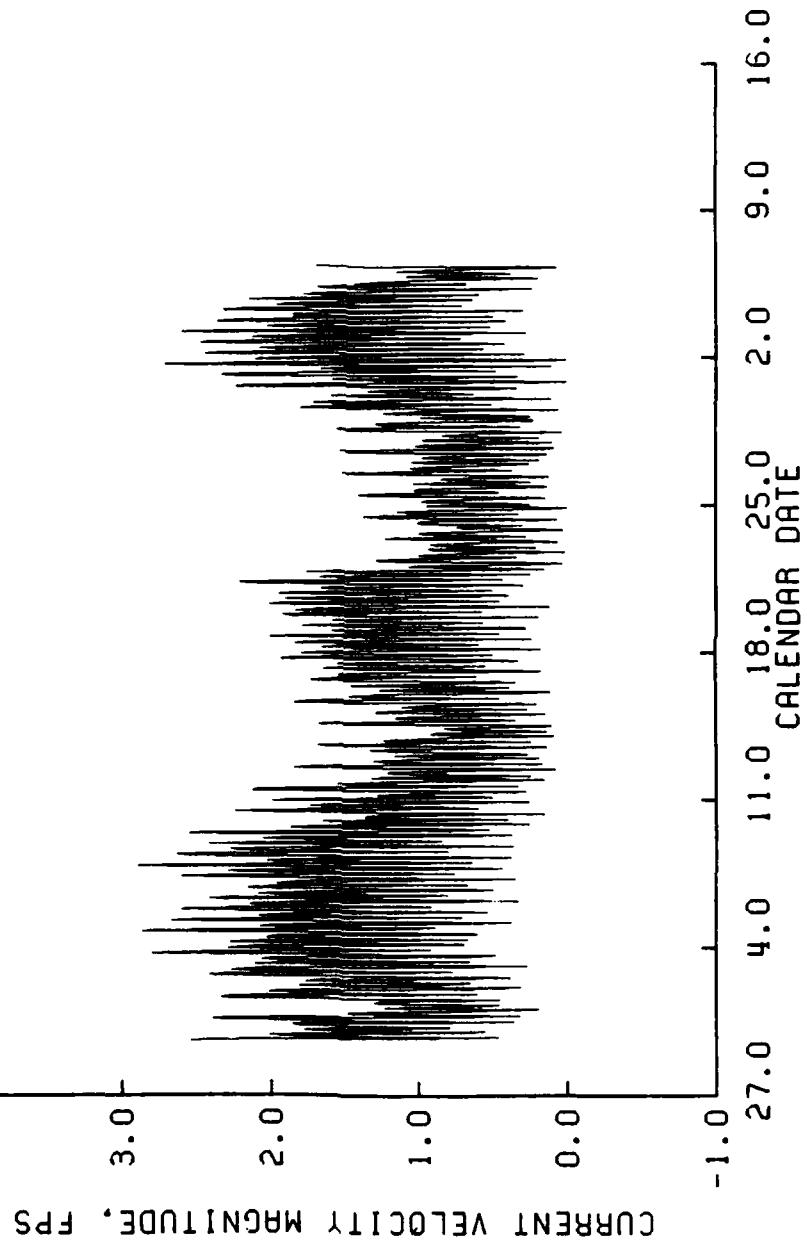
CURRENT VELOCITY MAGNITUDE, FPS



PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PI3B  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



PONCE DE LEON INLET PROJECT  
ENDECO 174. STATION P13C  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



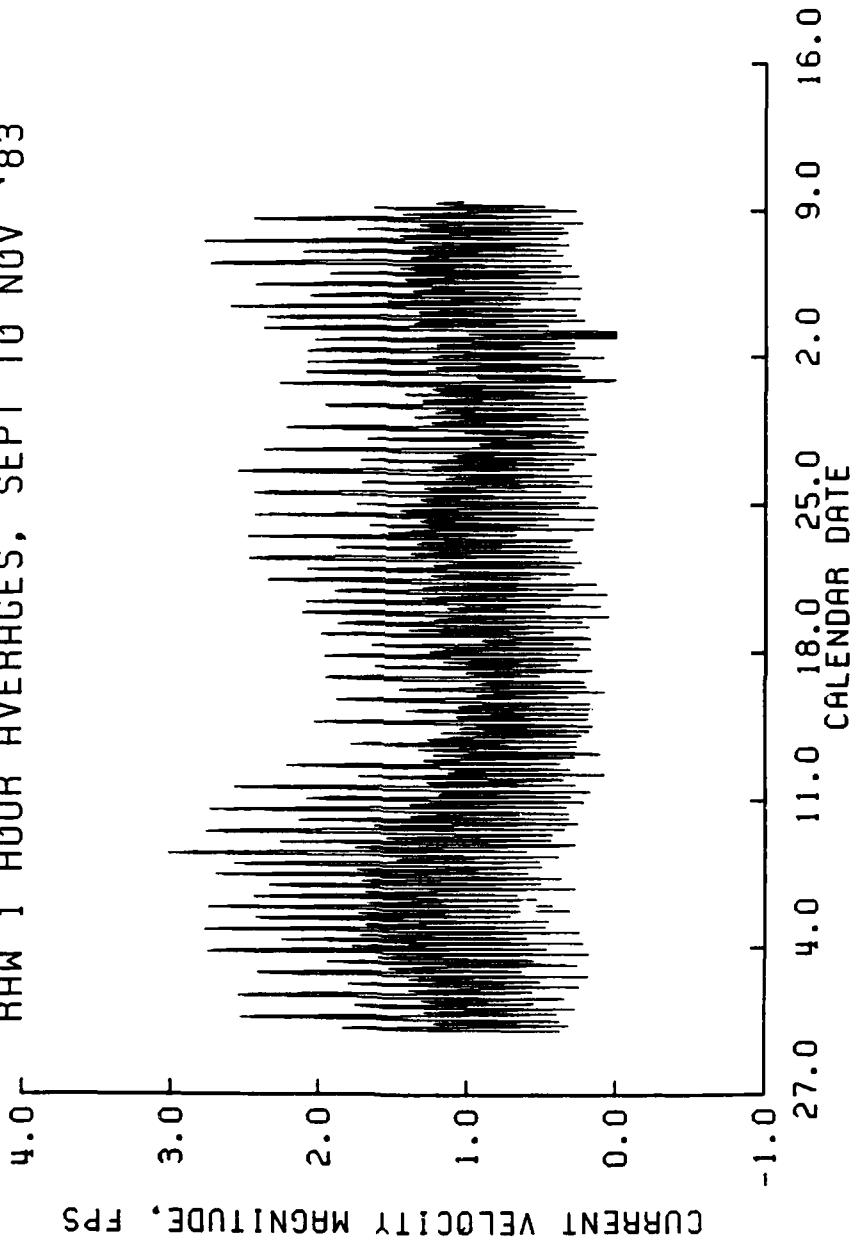
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ENDECO 174, STATION PIQAB  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83

CURRENT VELOCITY MAGNITUDE, FPS

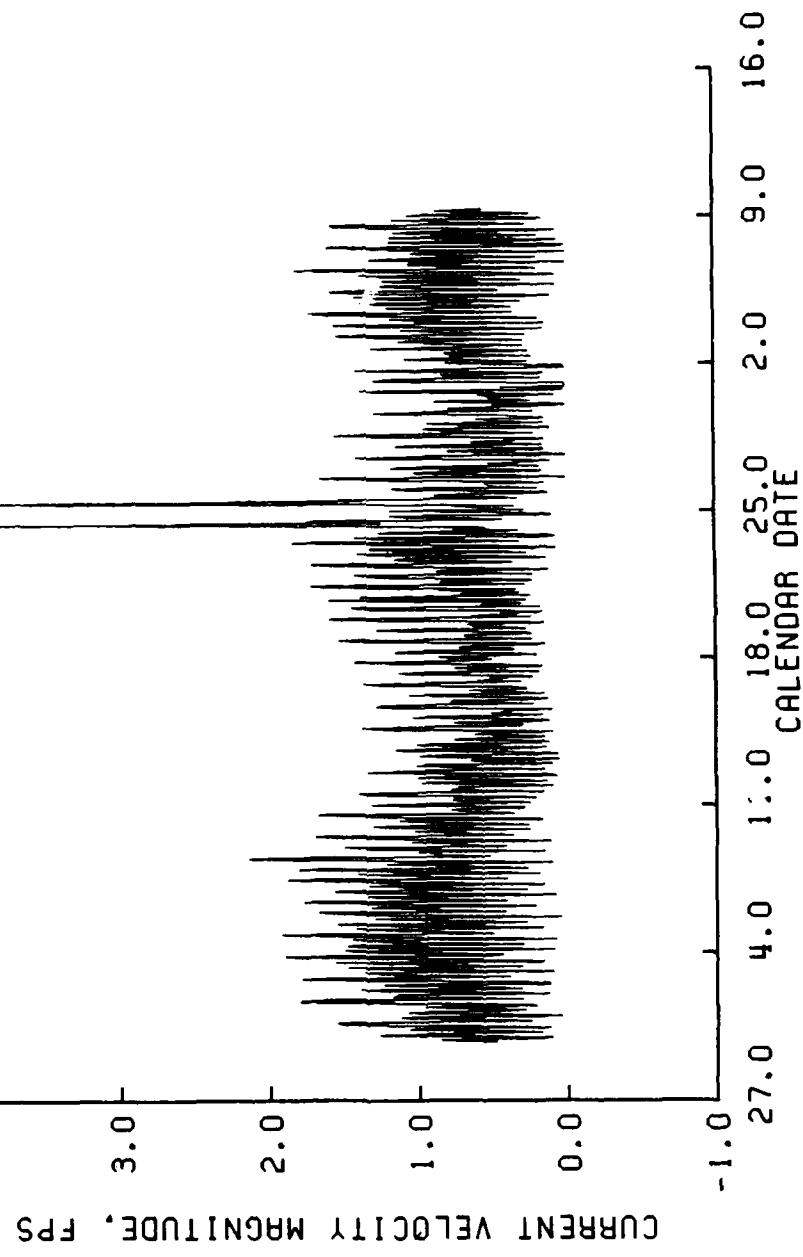
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CALENDAR DATE

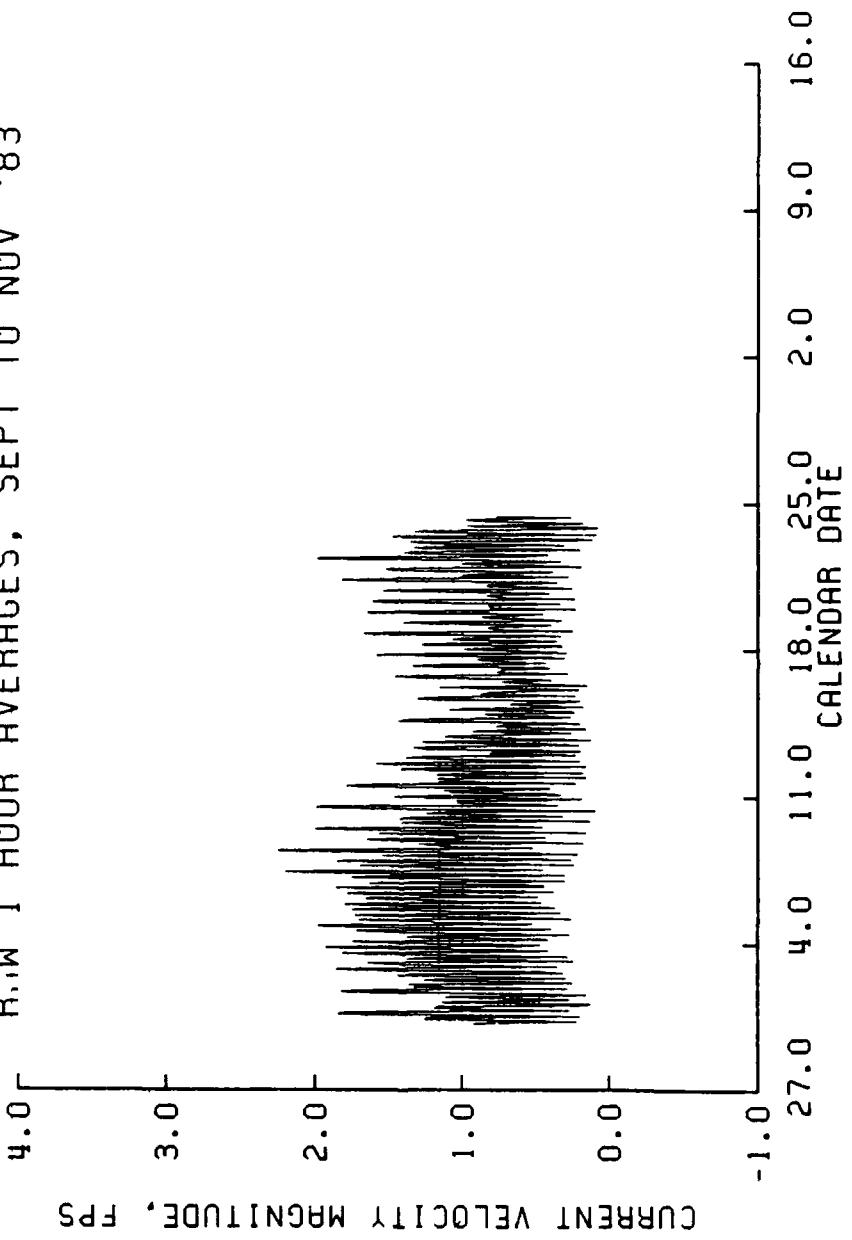
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ENDECO 174, STATION PIYAT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



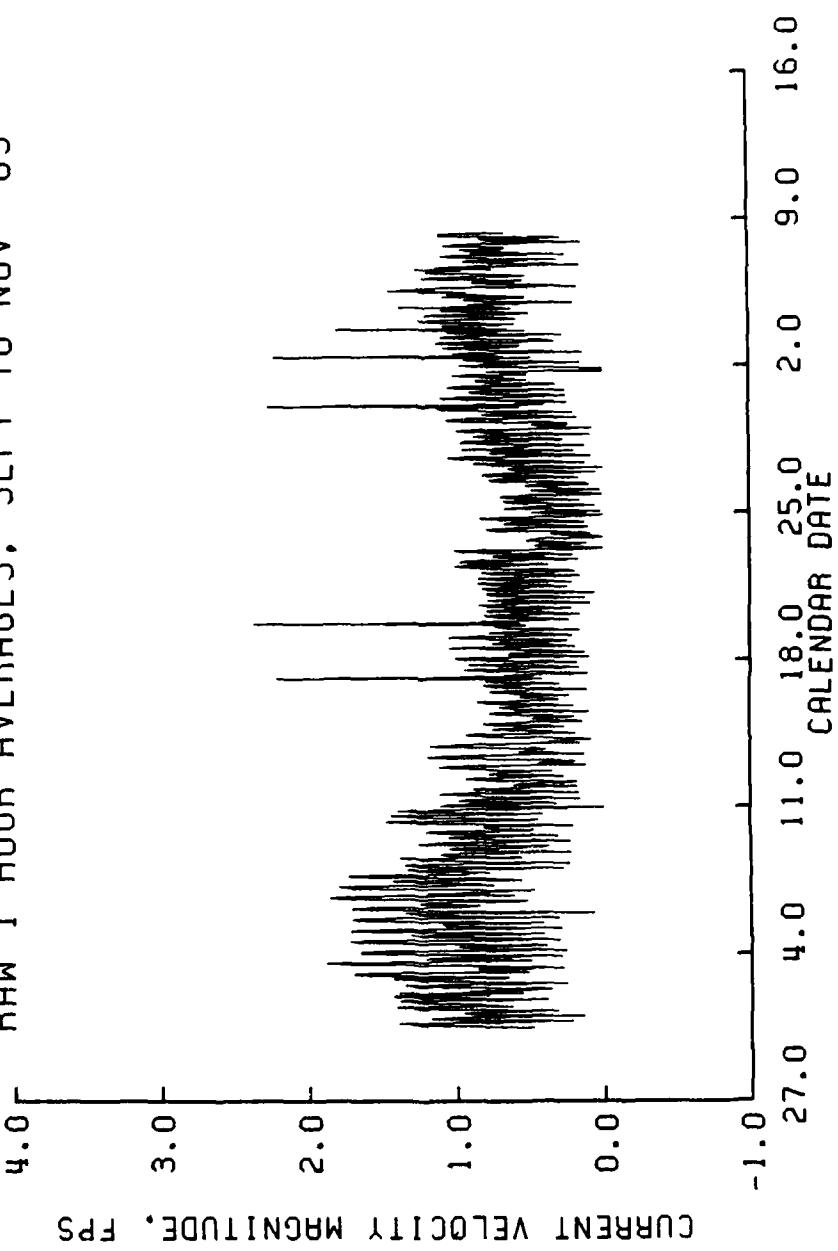
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PI4BB  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



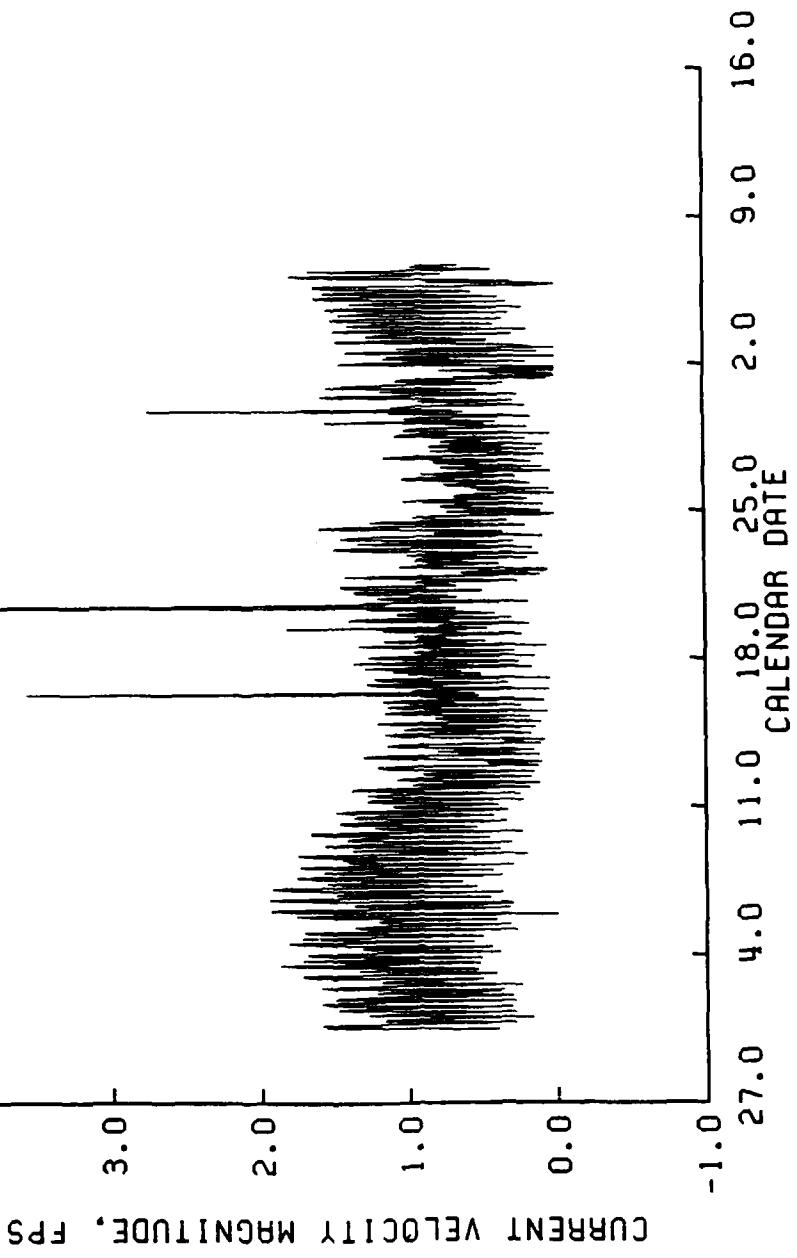
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PI4BT  
R.W 1 HOUR AVERAGES, SEPT TO NOV '83



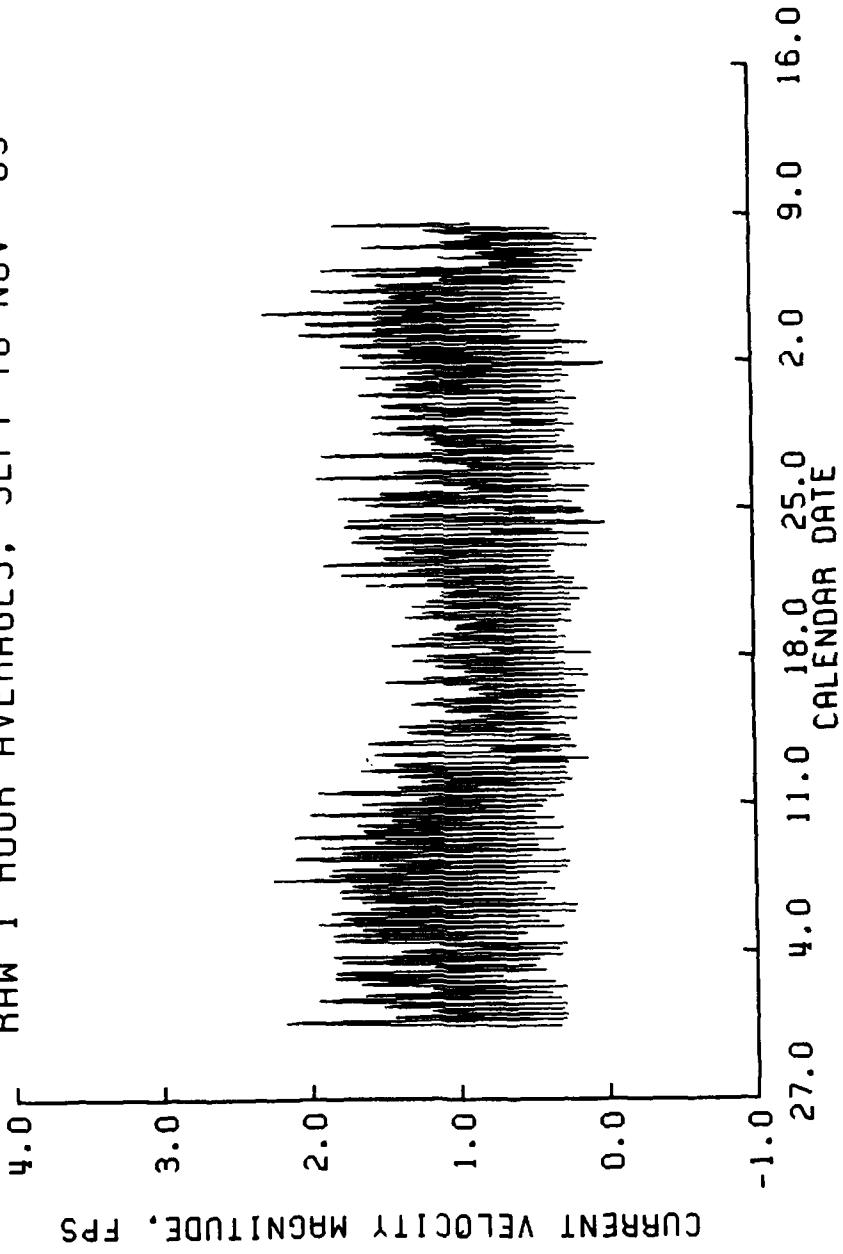
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ENDECO 174, STATION P15A  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



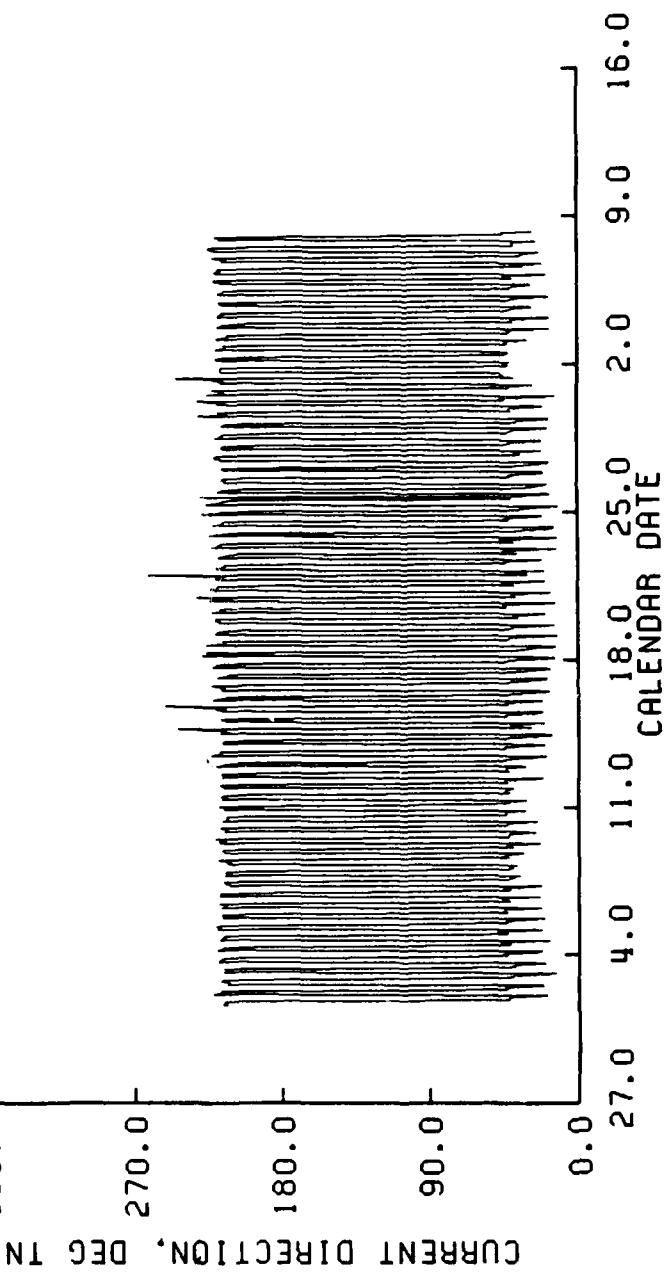
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ENDECO 174, STATION P15B  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



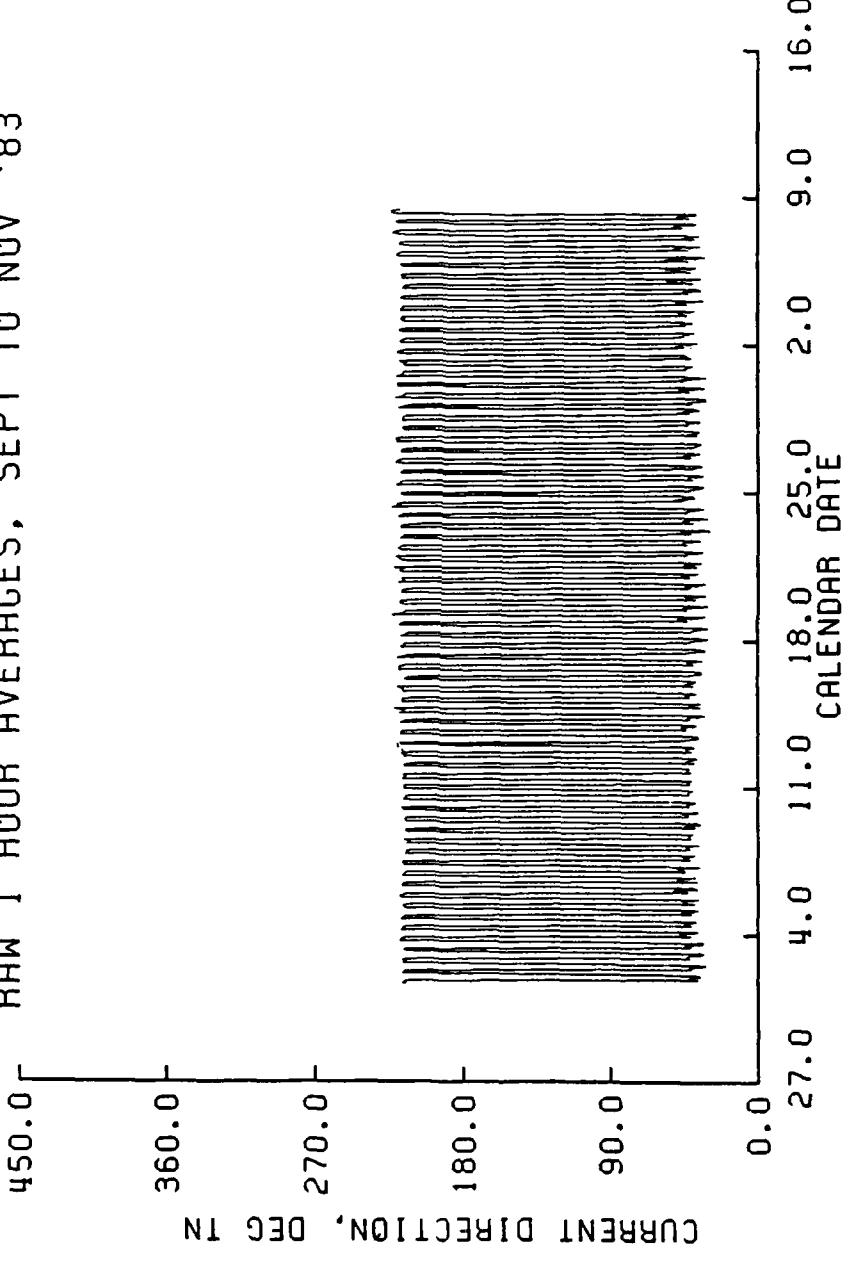
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ENDECO 1174, STATION PI5C  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



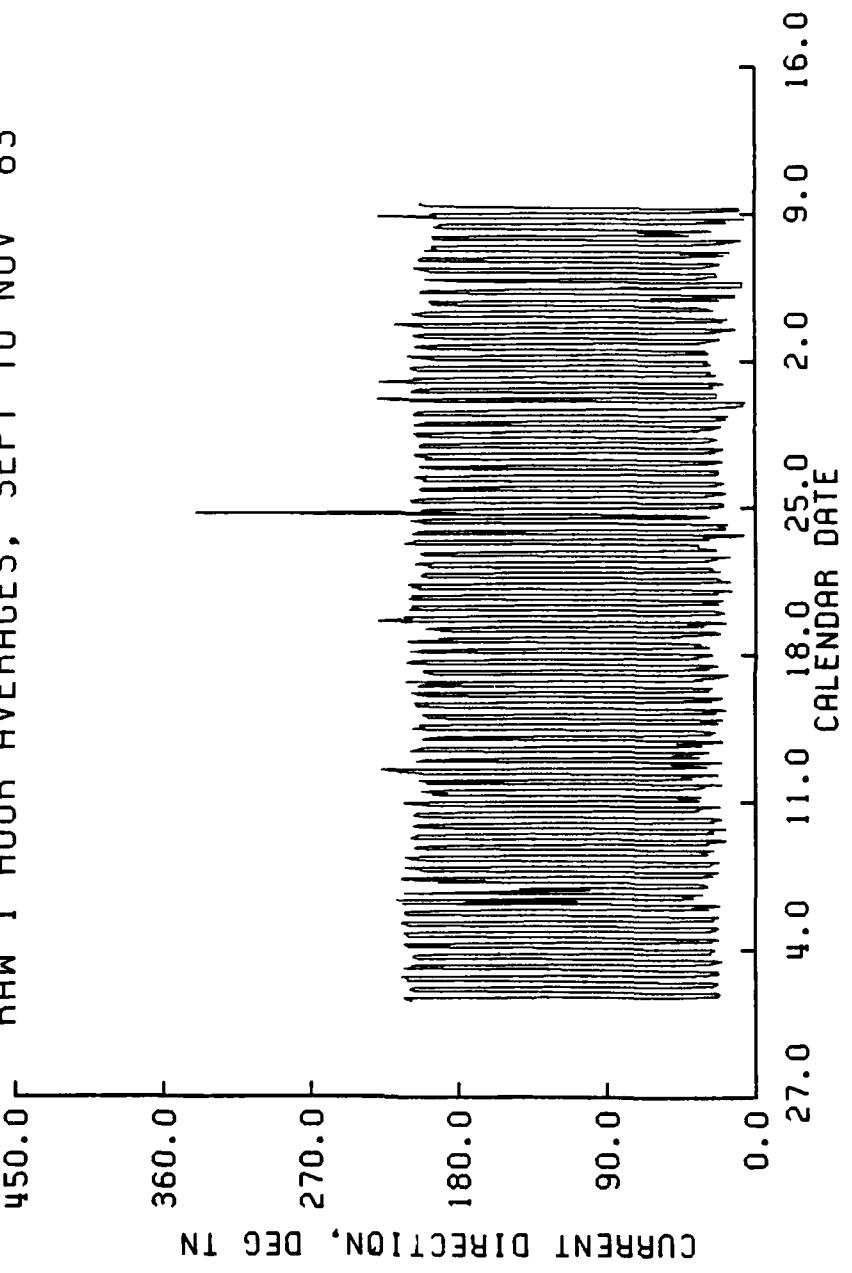
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ENDECO 174, STATION P12AB  
RAW 1 HOUR AVERAGES, SEPT 10 NOV '83



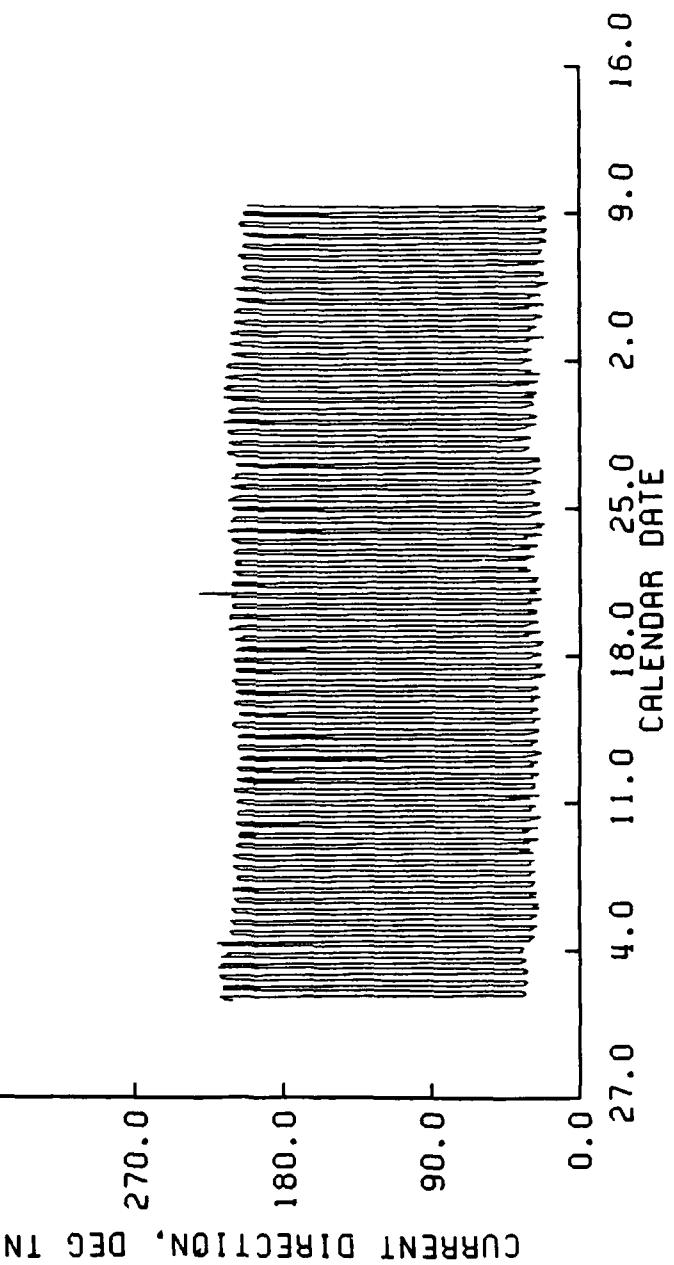
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ENDECO 174, STATION PI2AT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



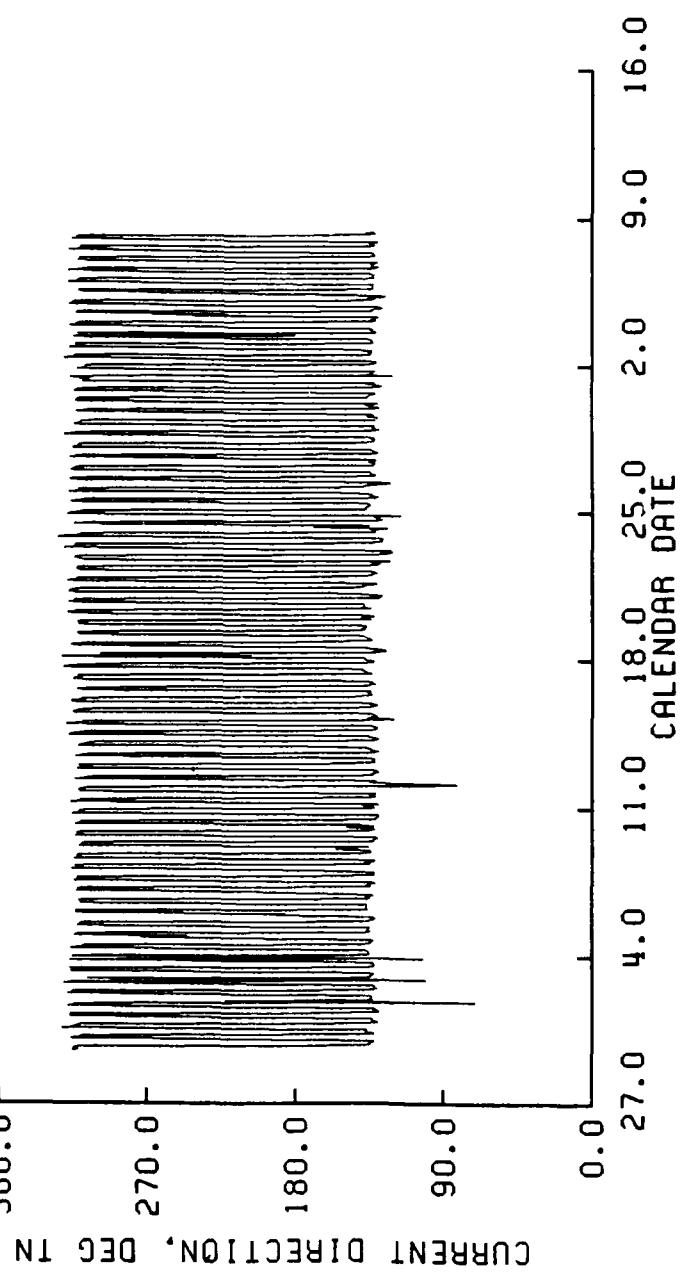
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ENDECO 174, STATION P12BB  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



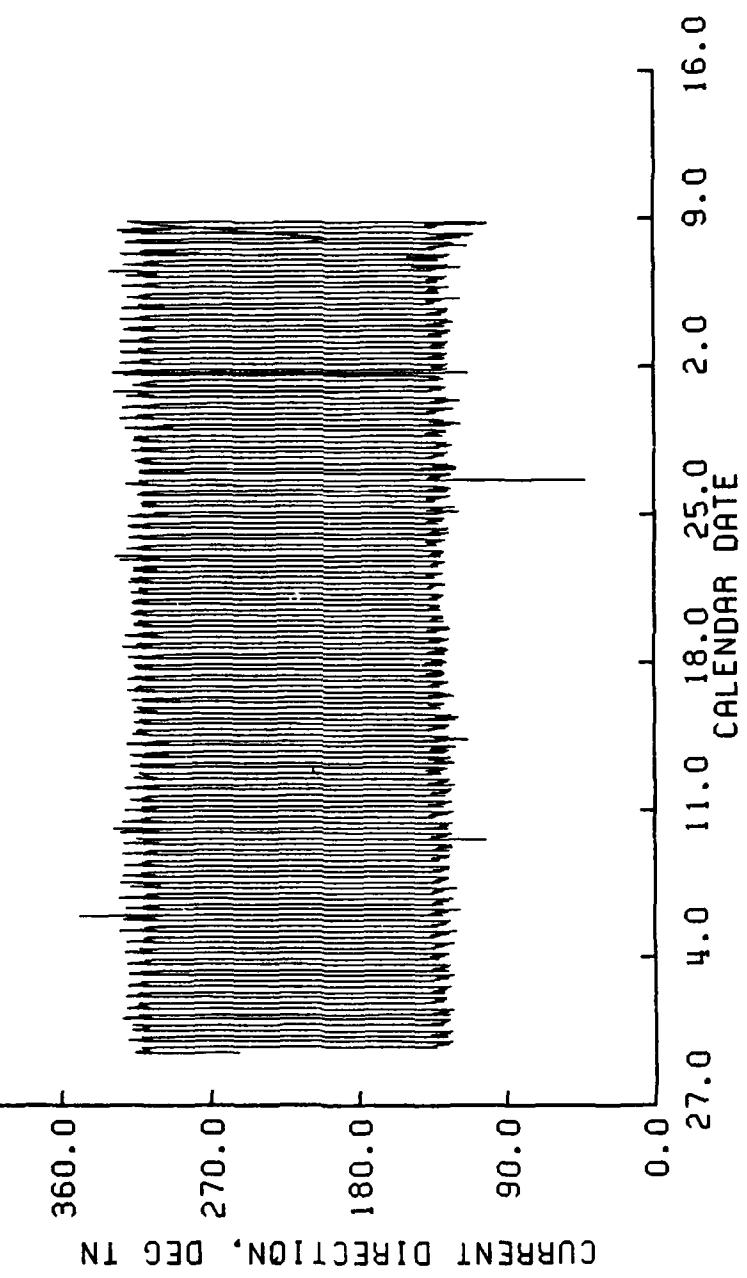
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ENDECO 174. STATION PI2BT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



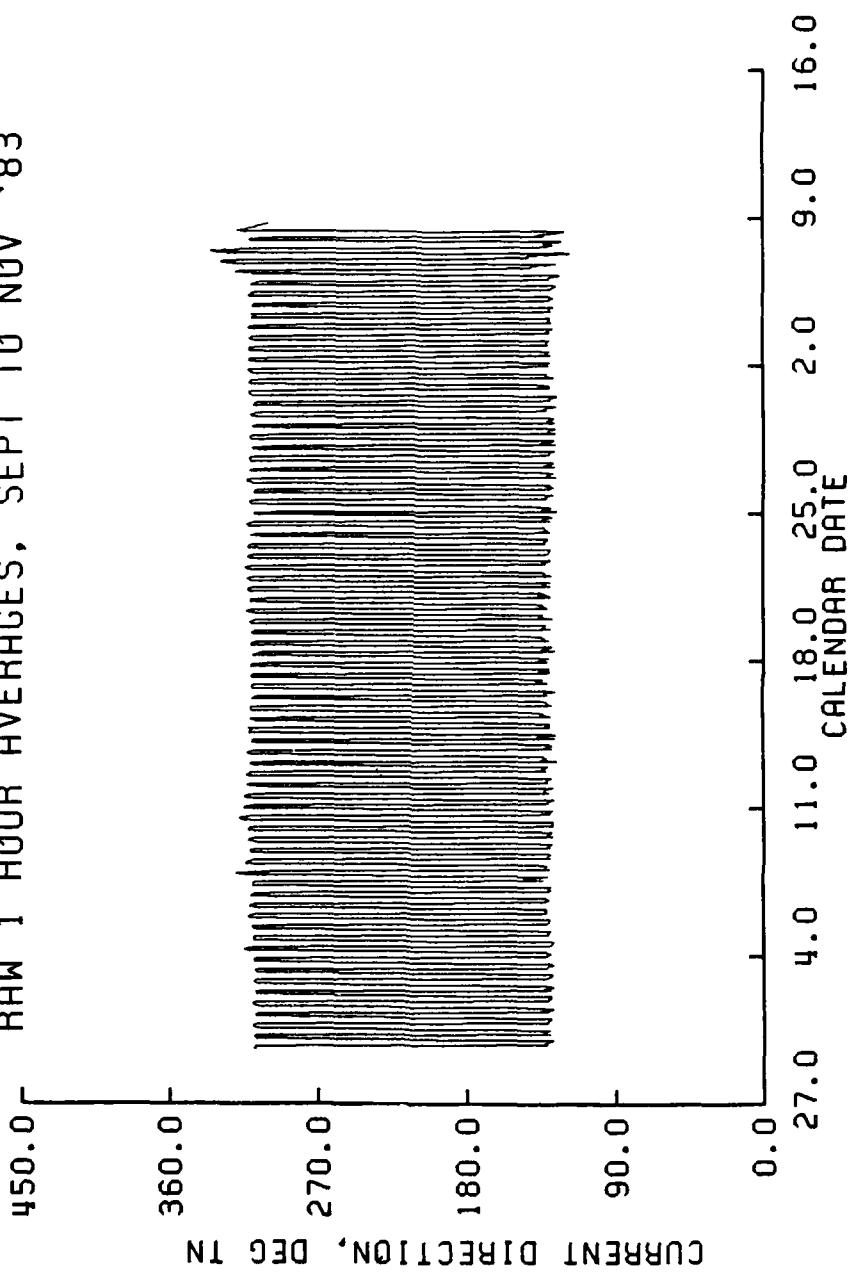
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ENDECO 174, STATION P13A  
RAW 1 HOUR AVERAGES, SEPT 10 NOV 83



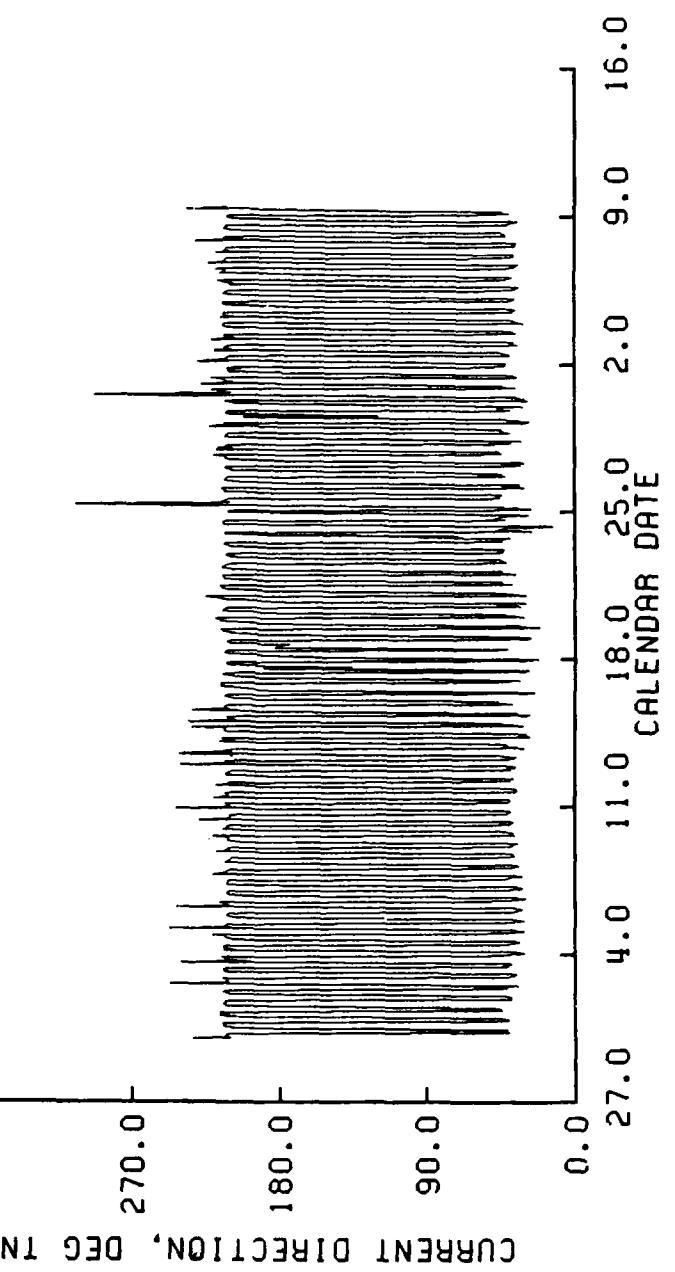
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ENDECO 174, STATION PI3B  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



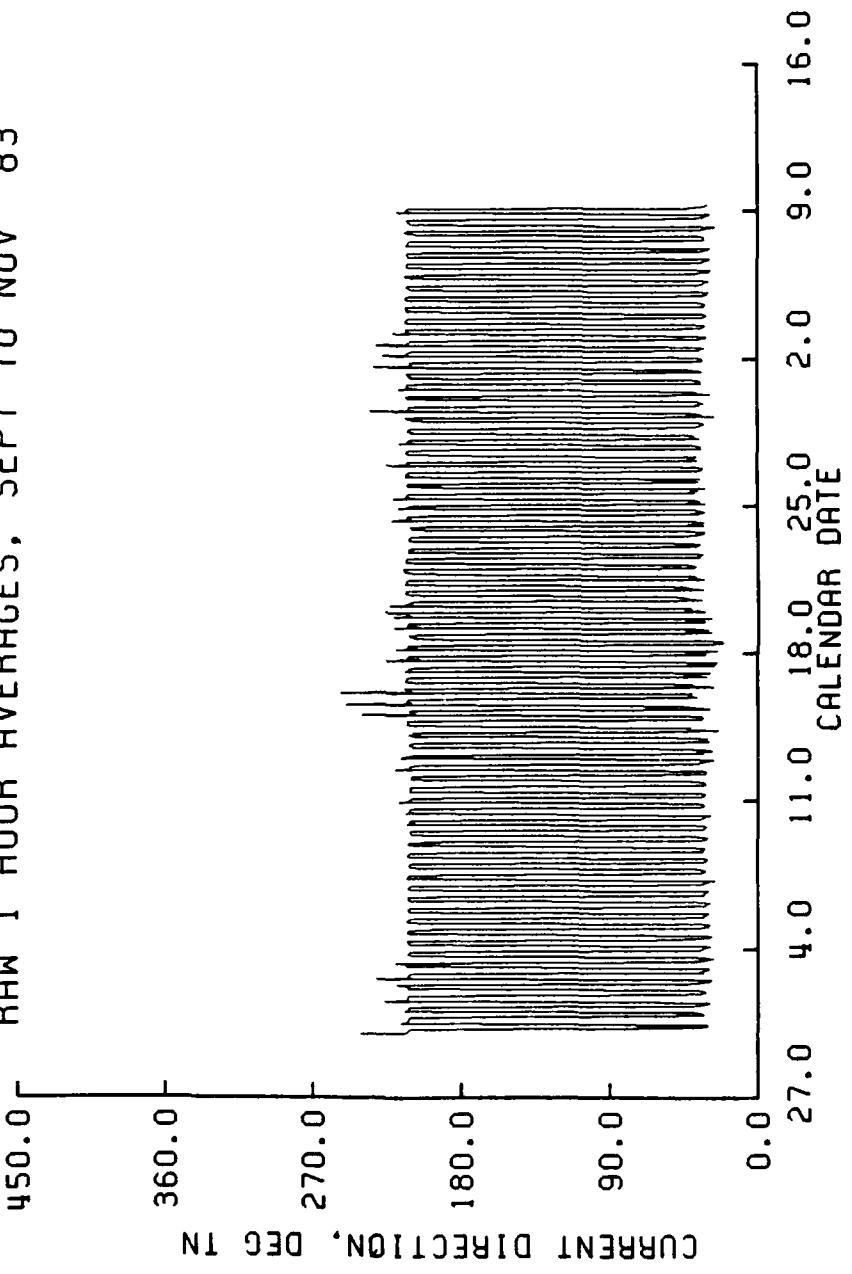
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ENDEC0 174, STATION P13C  
RAW 1 HOUR AVERAGES, SEPT 10 NOV '83



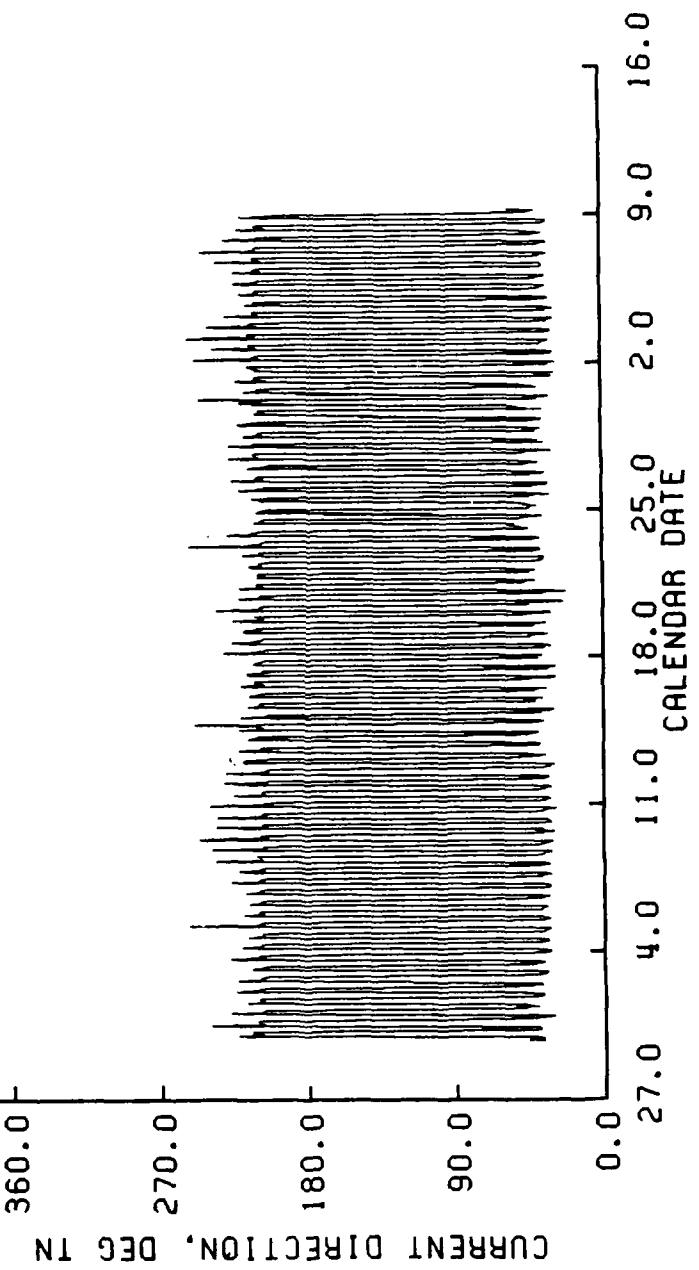
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ENDECO 174. STATION PI4AB  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



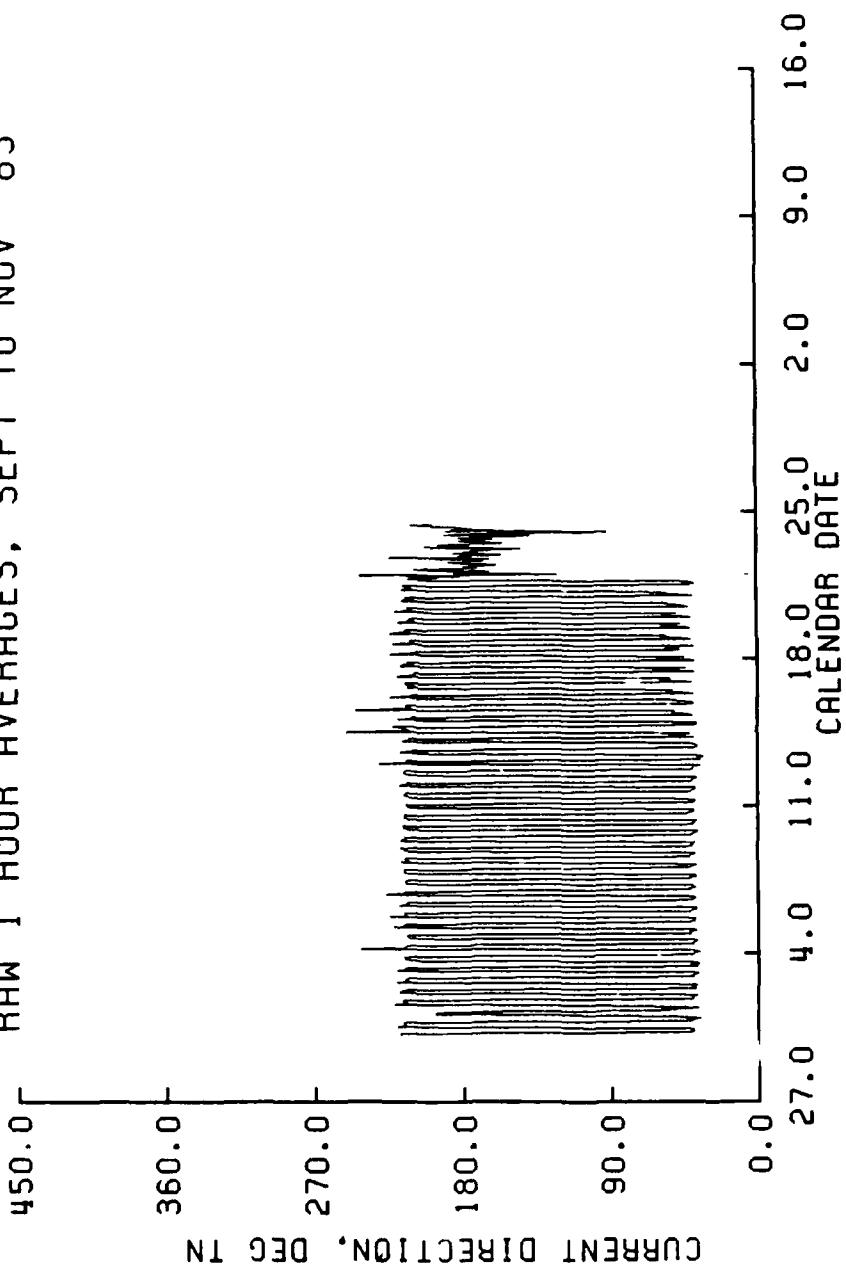
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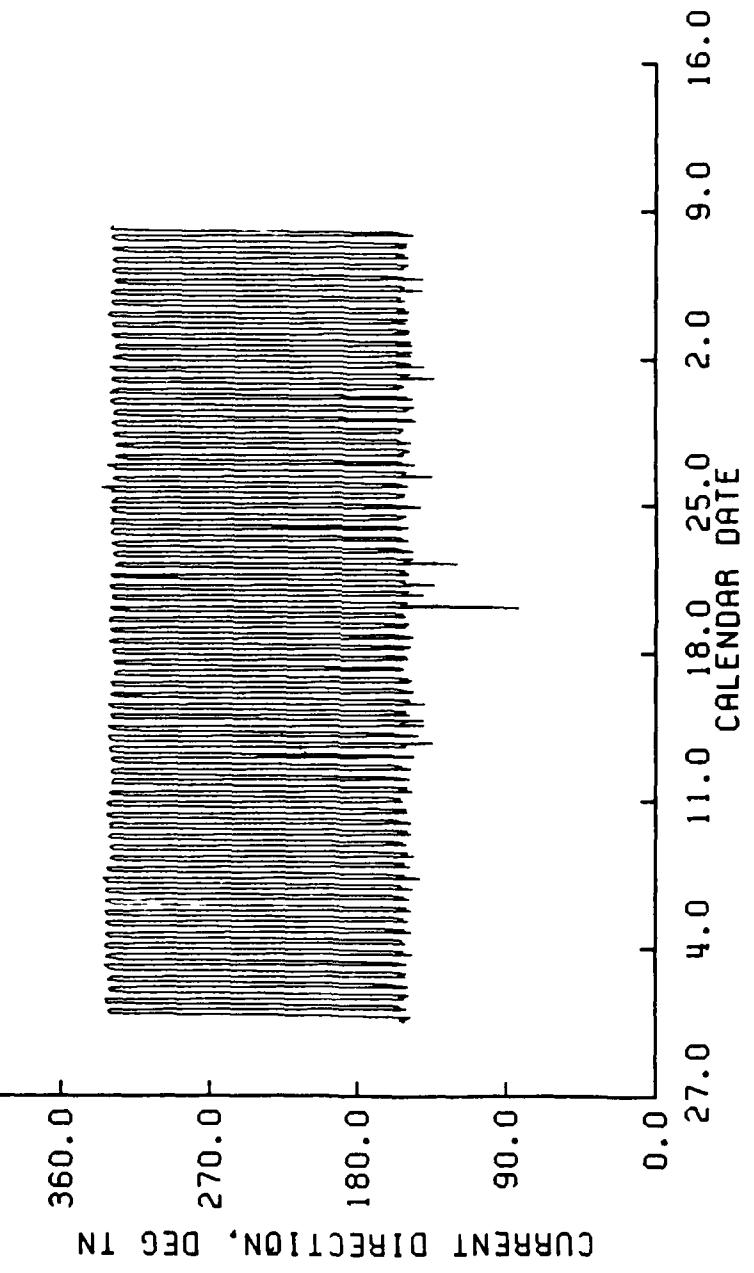
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ENDECO 174, STATION PI4BB  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



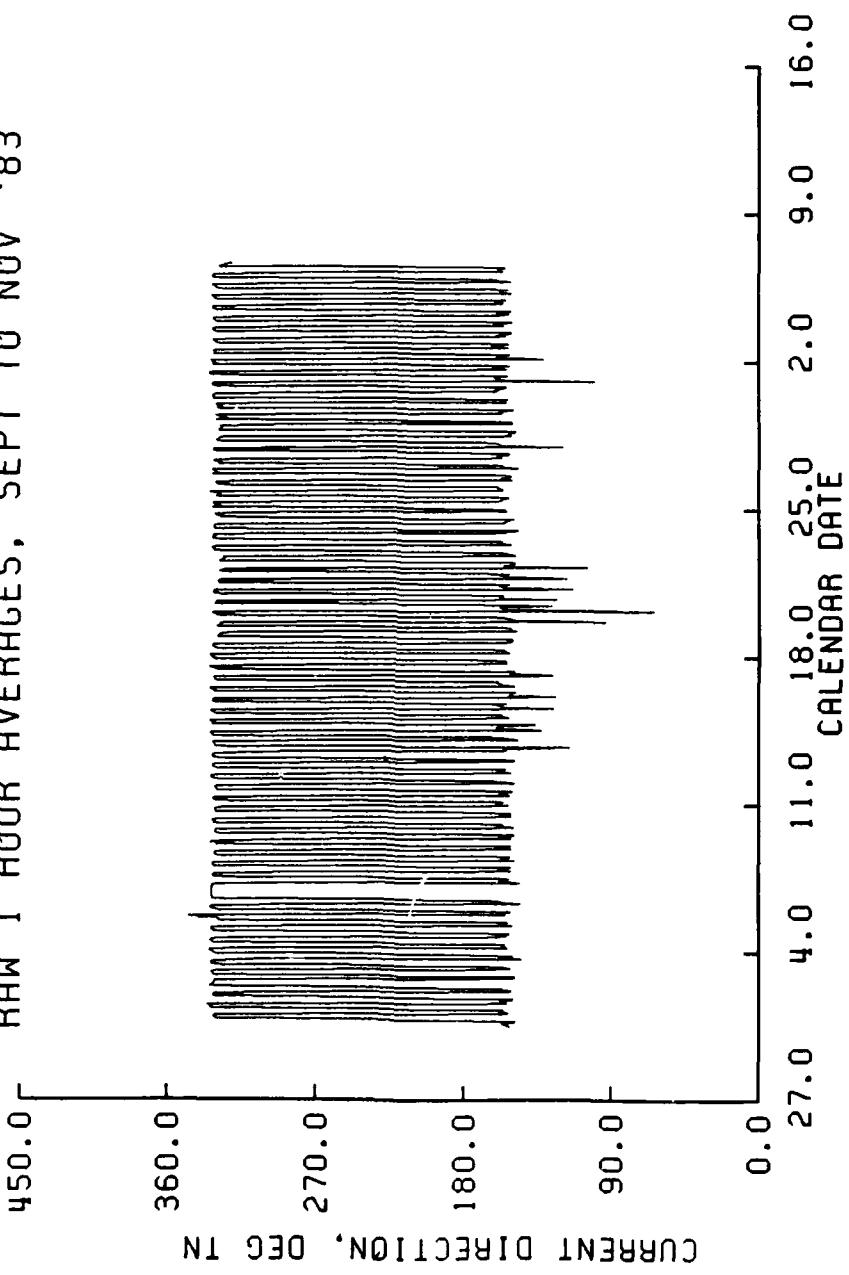
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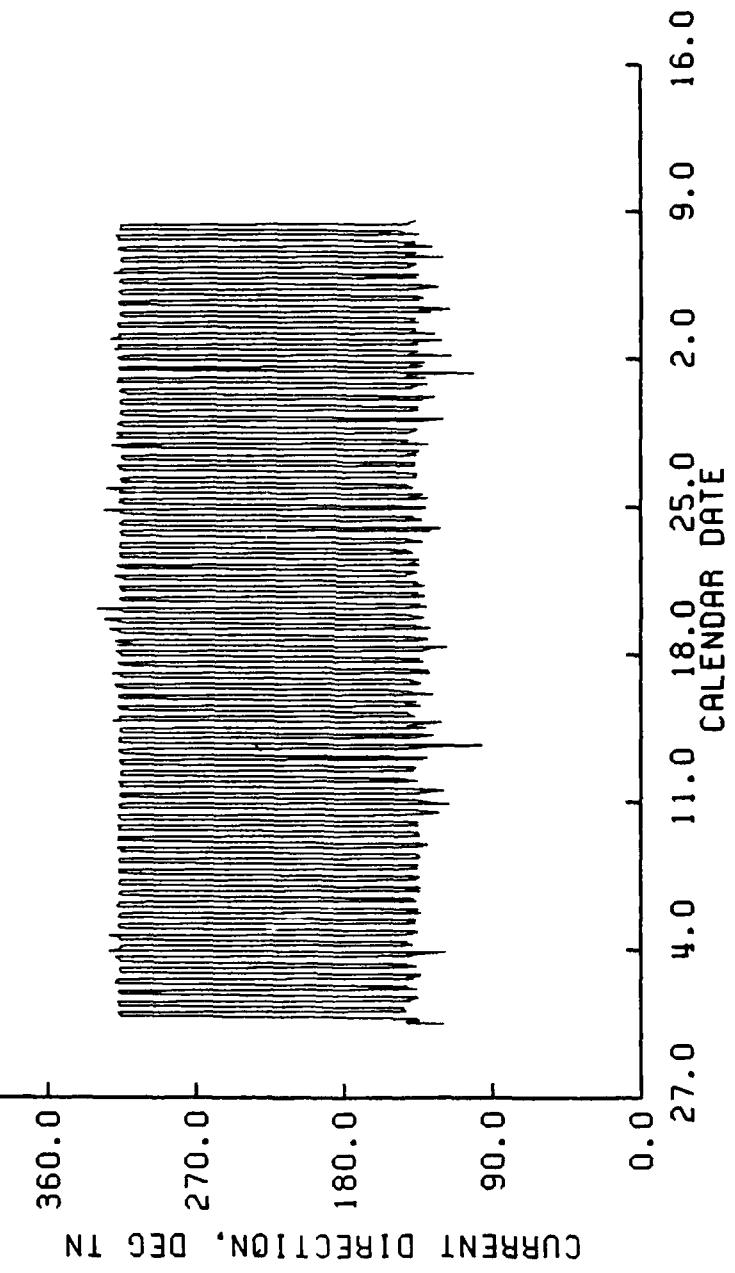
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RAW 1 HOUR AVERAGES, SEPT TO NOV '83



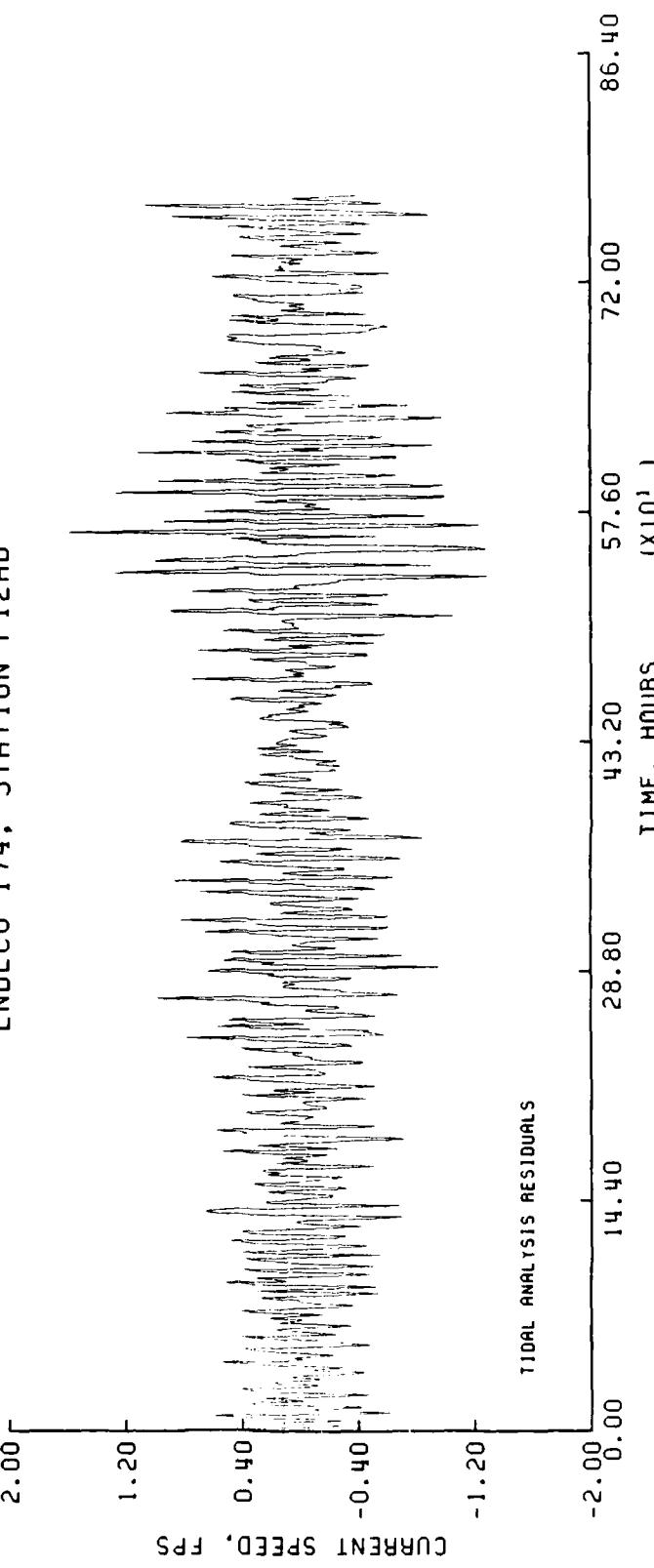
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ENDECO 174, STATION P15B  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



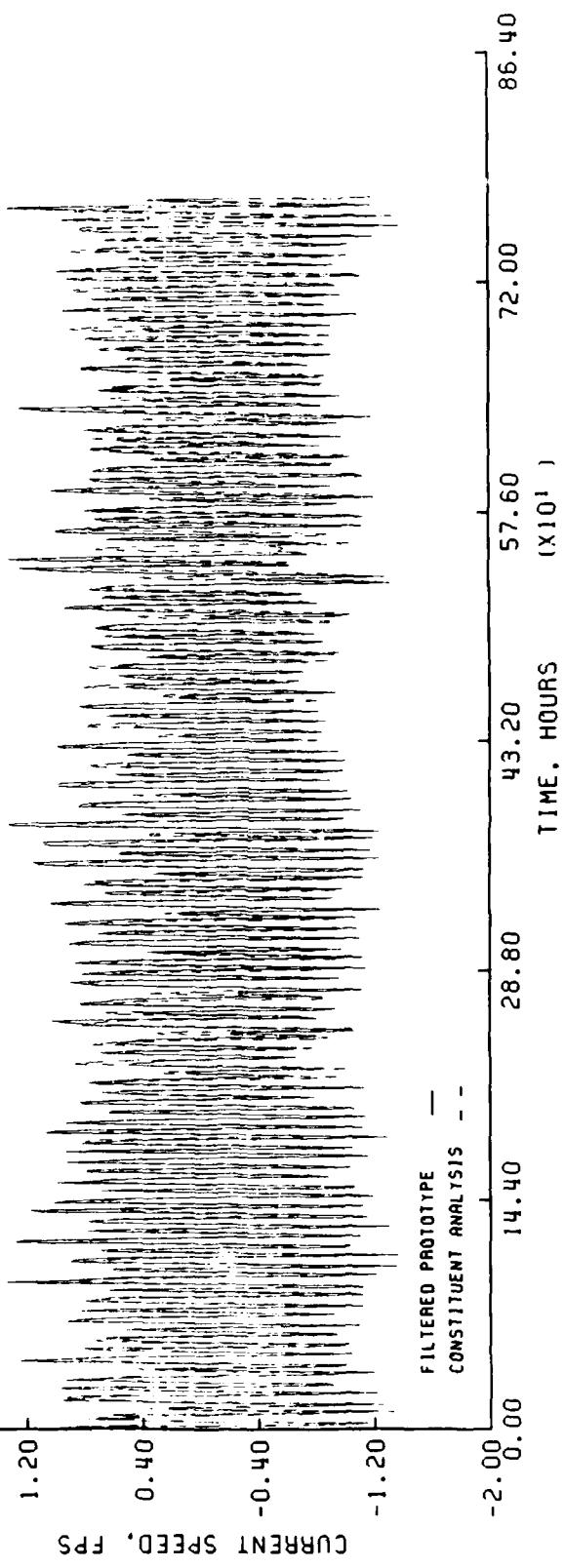
PONCE DE LEON INLET PROJECT  
IDECO 174, STATION P15C  
MID 1 HOUR AVERAGES, SEPT TO NOV '83



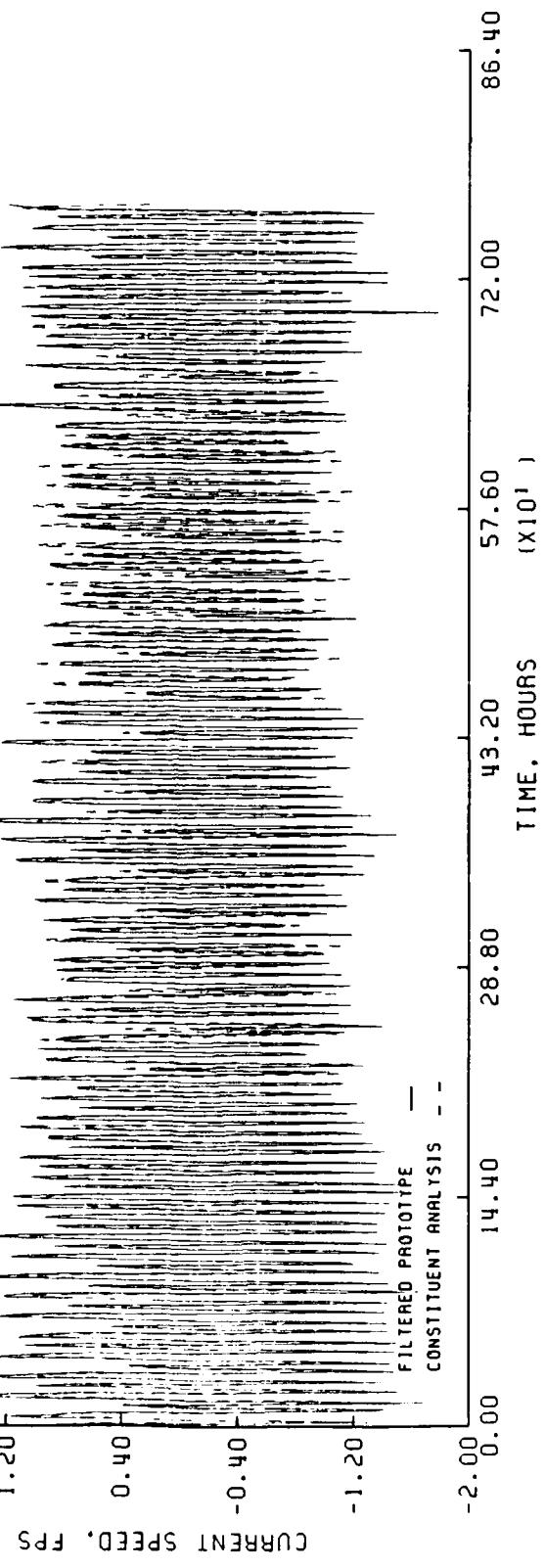
TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P12AB



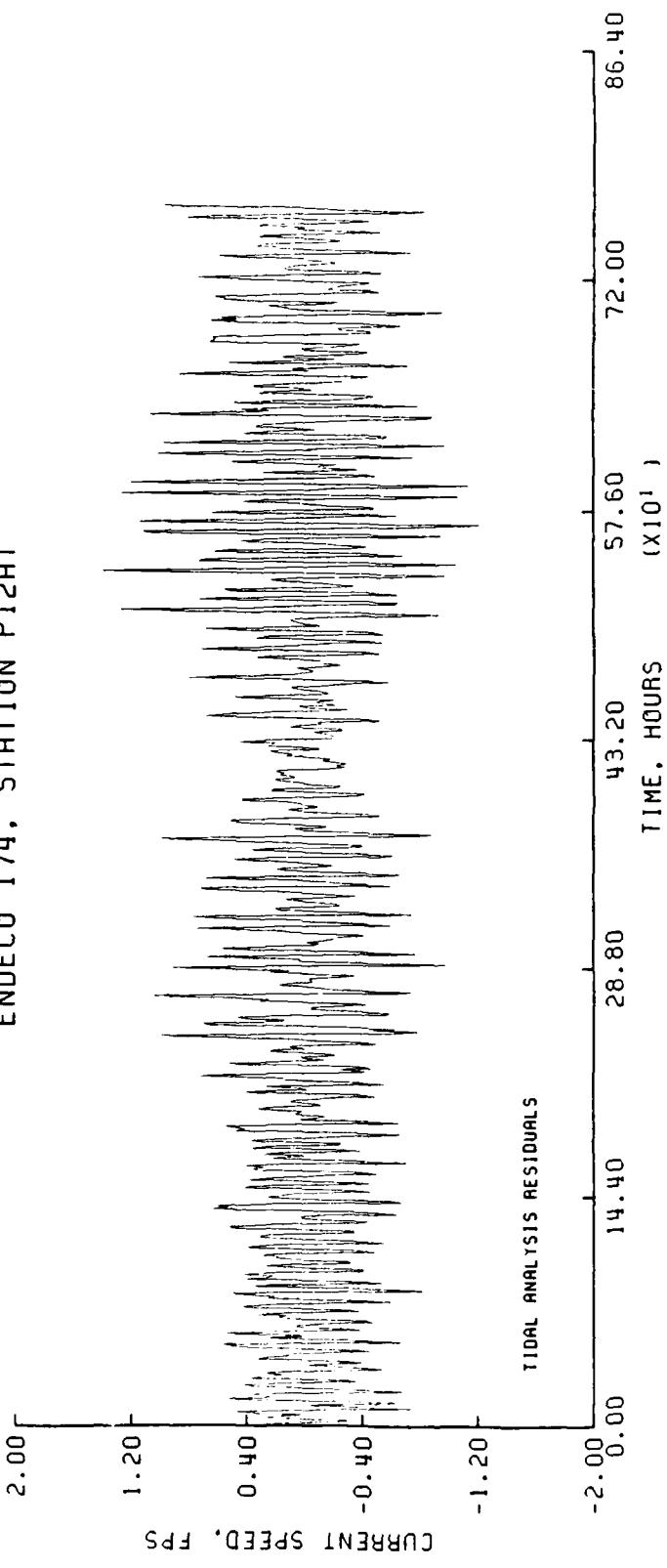
TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P12AB



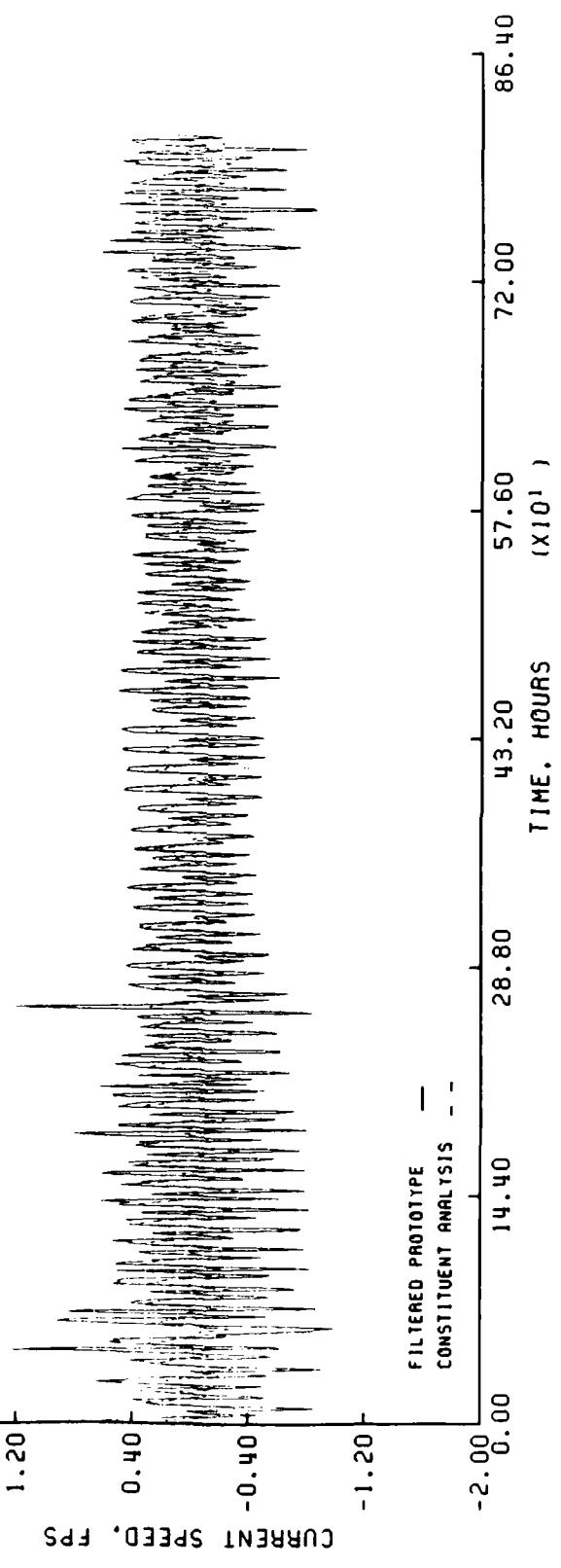
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PONCE DE LEON INLET PROJECT  
ENDECO 174. STATION P12AT



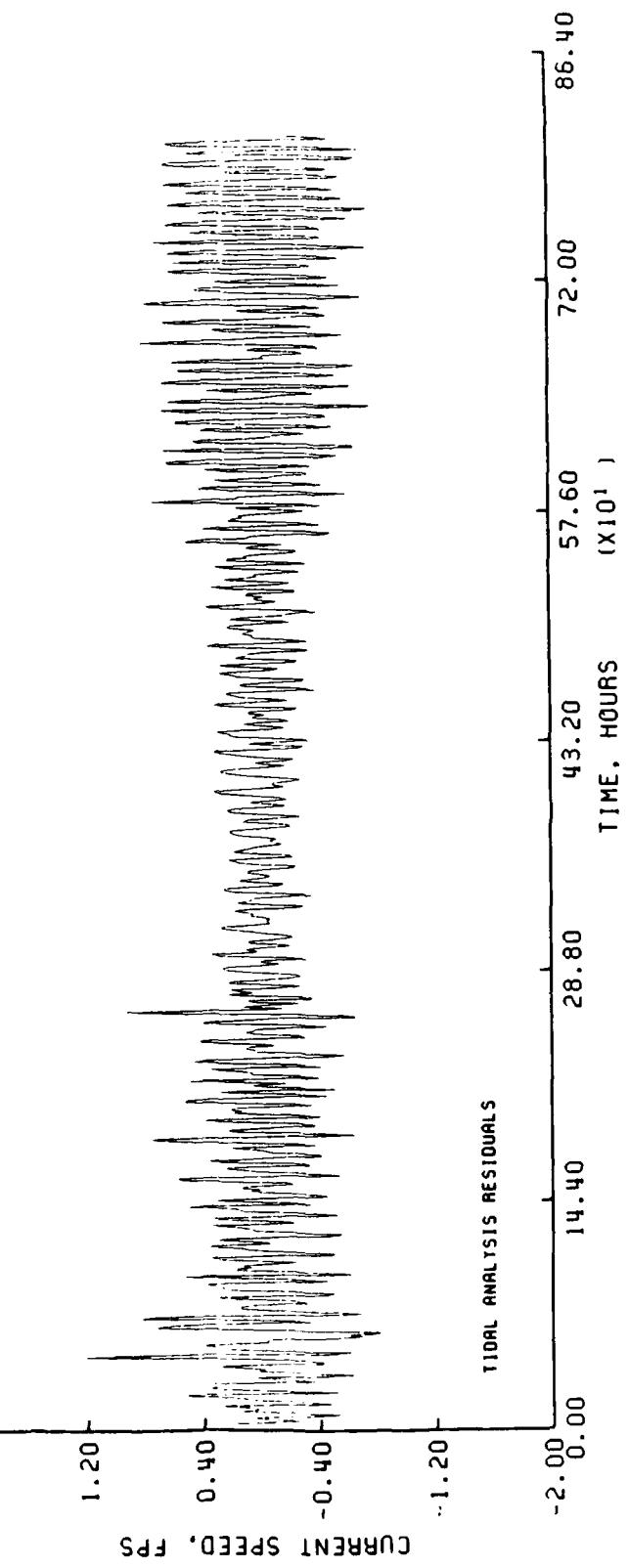
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PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P12AT



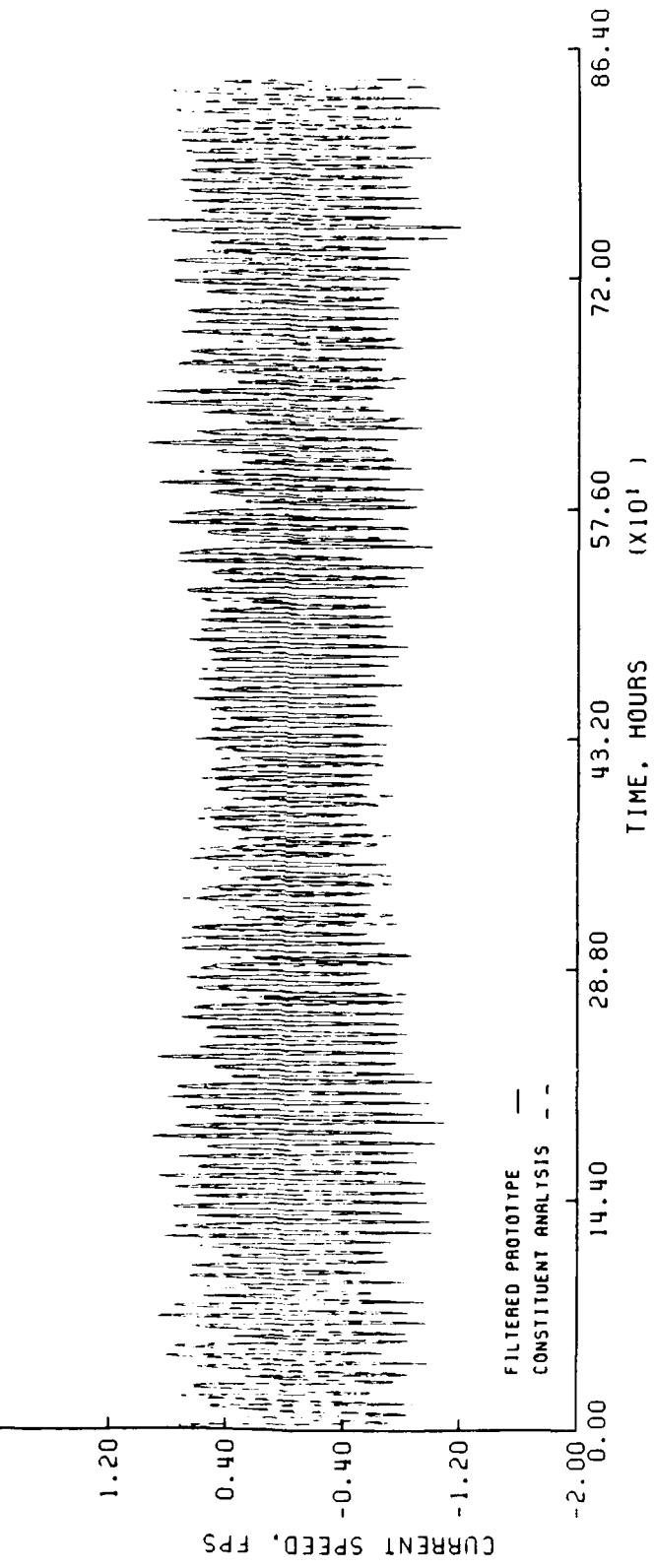
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PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P13A



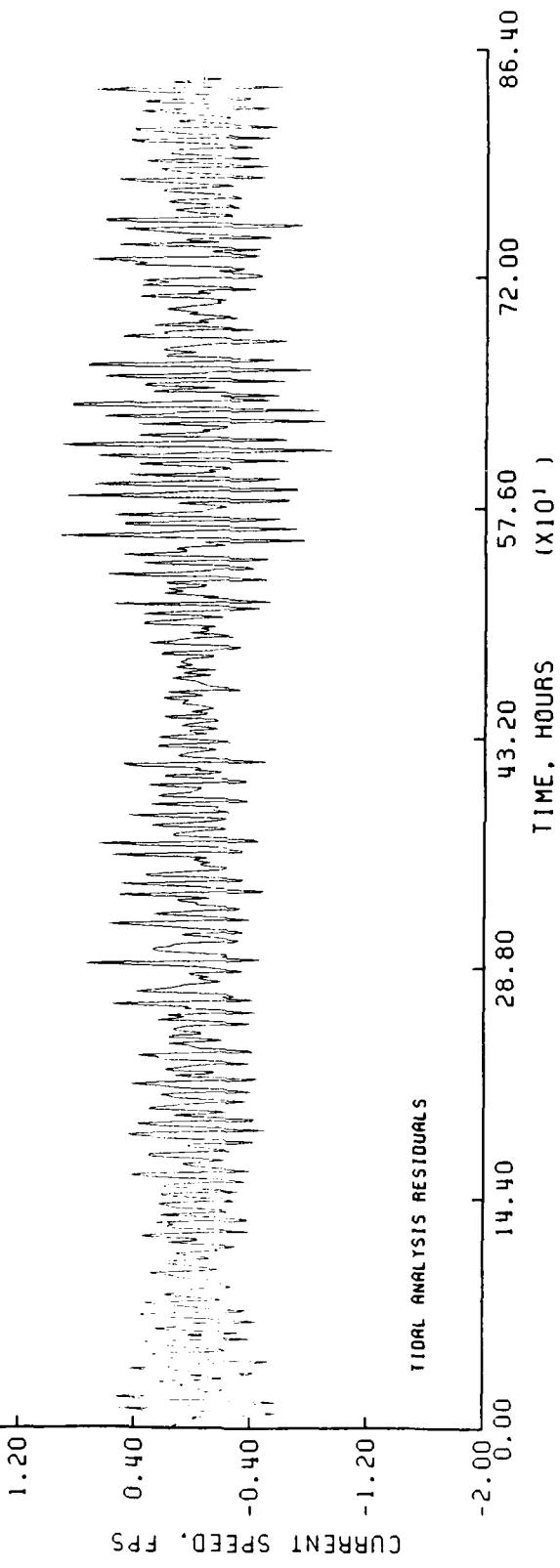
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PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P13A



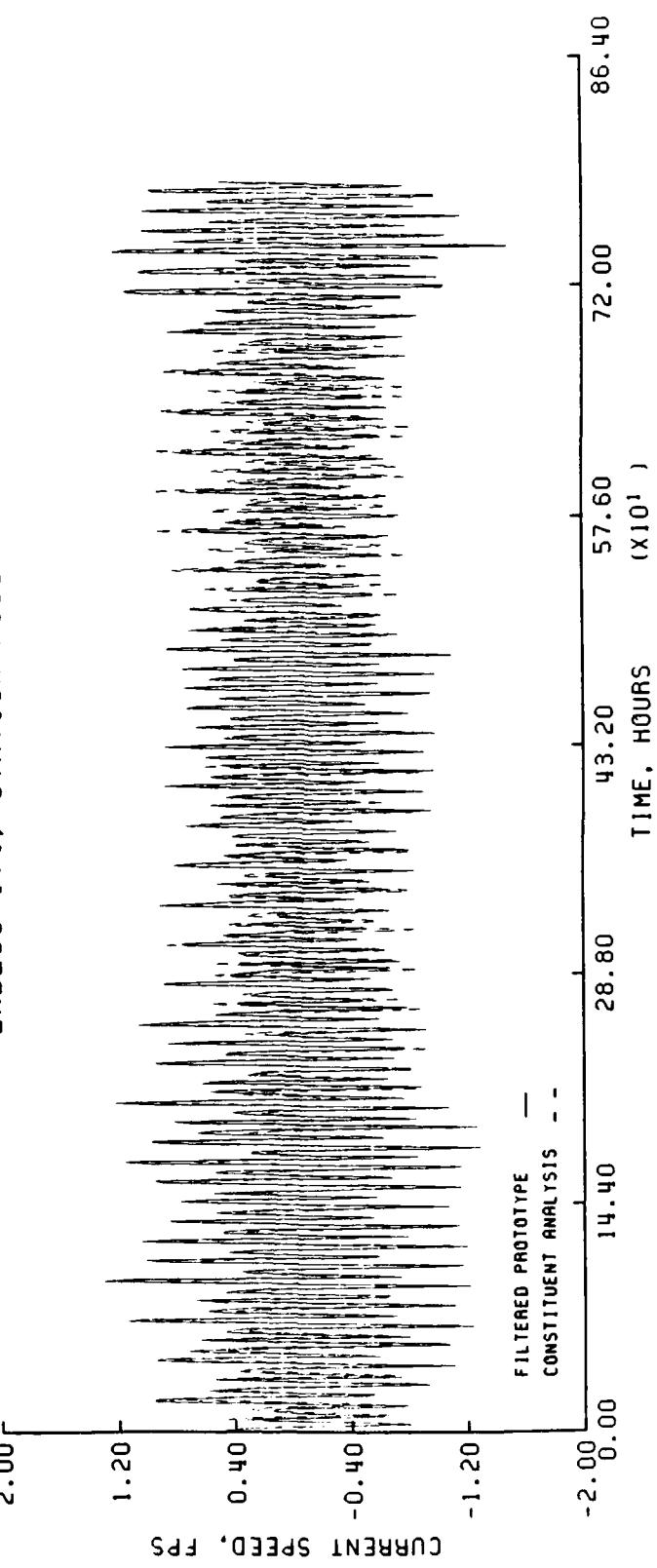
TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PI3B



TIDAL HARMONIC ANALYSIS  
PONCE DE LEÓN INLET PROJECT  
ENDECO 174. STATION P13B



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P13C



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P13C

2.00

1.20

0.40

-0.40

-1.20

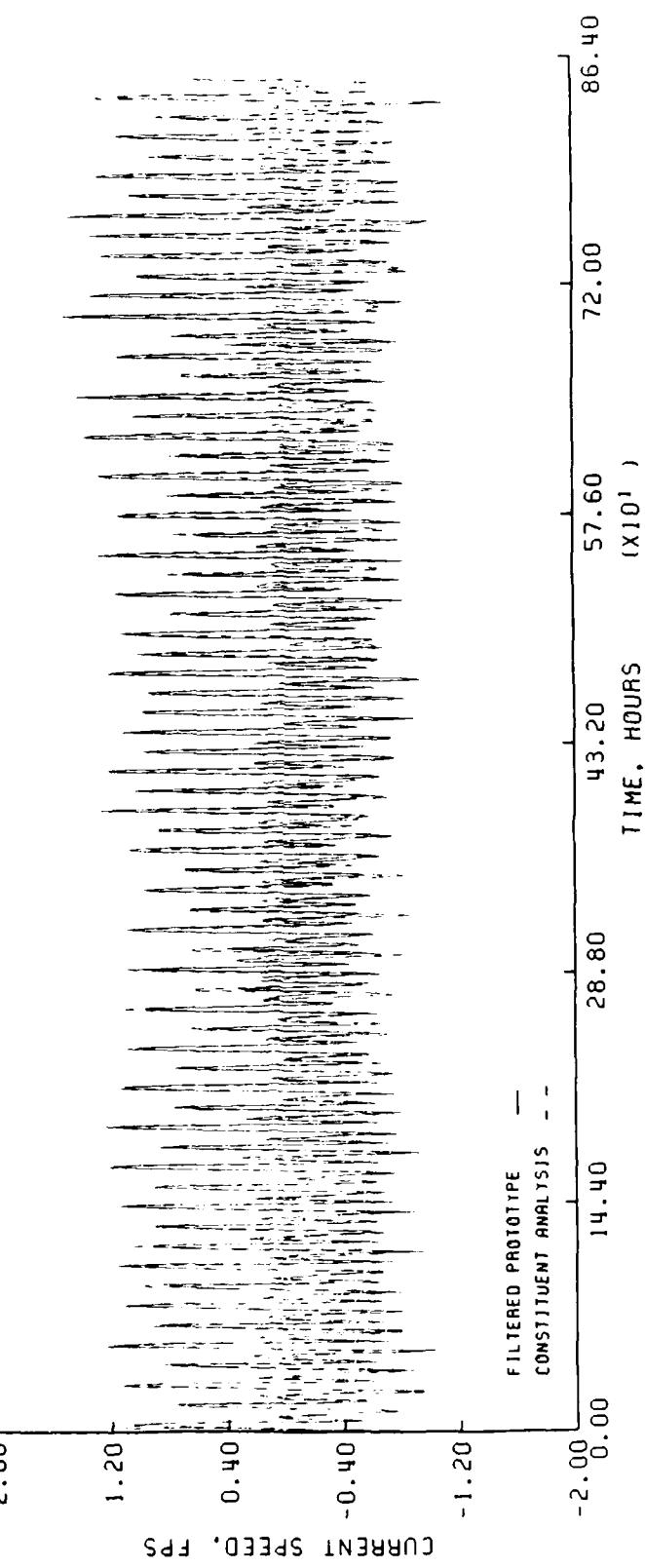
CURRENT SPEED, FPS

TIDAL ANALYSIS RESIDUALS

-2.00      0.00      14.40      28.80      43.20      57.60      72.00      86.40

TIME, HOURS  
(X10<sup>1</sup>)

TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PI4AB



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PI4AB

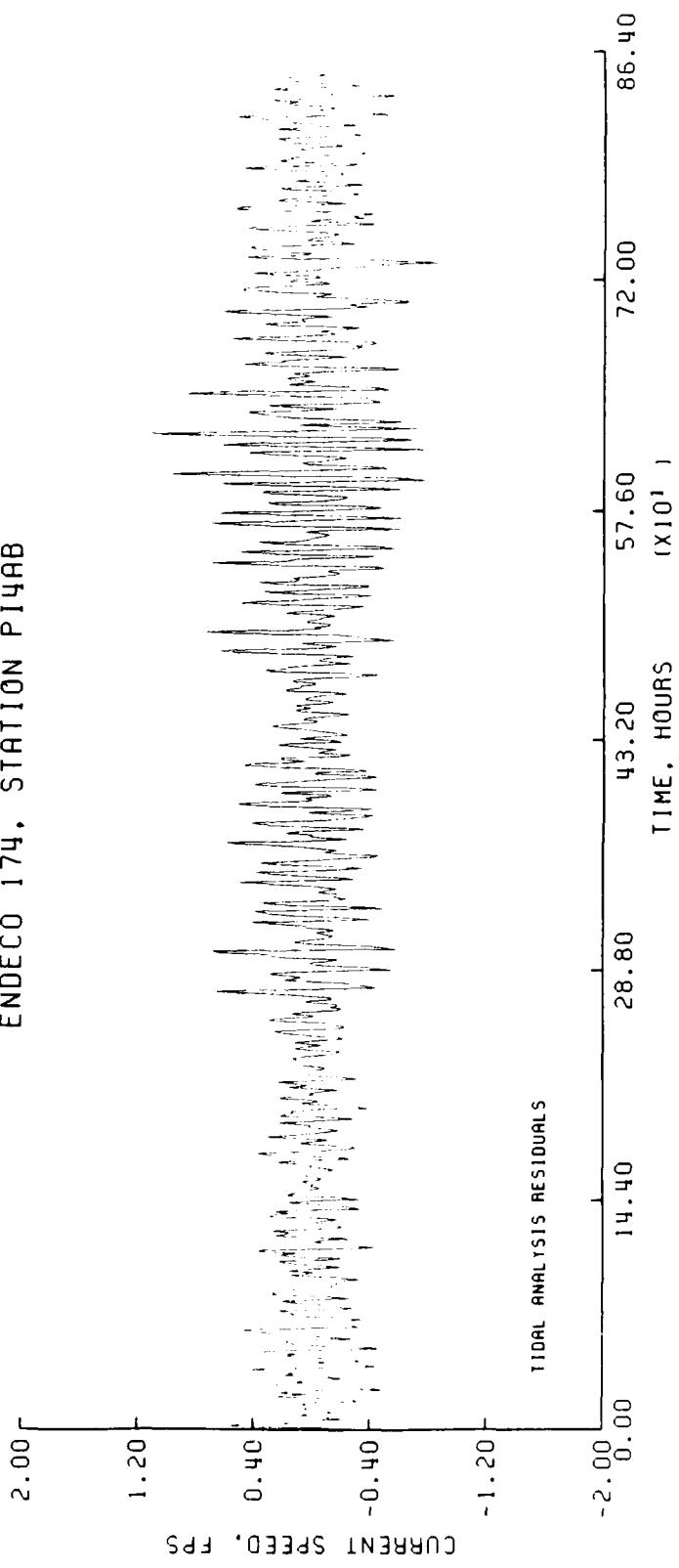


PLATE 87

TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174. STATION PI4AT

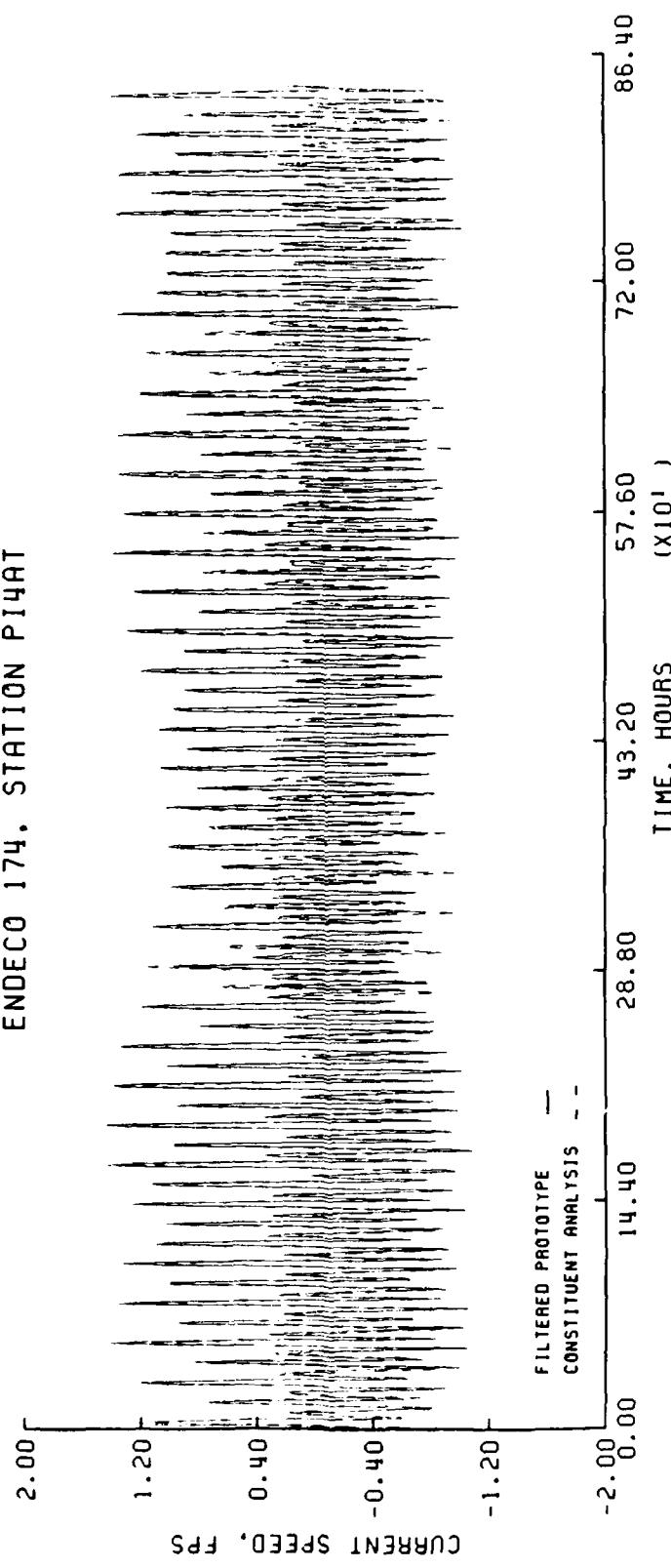
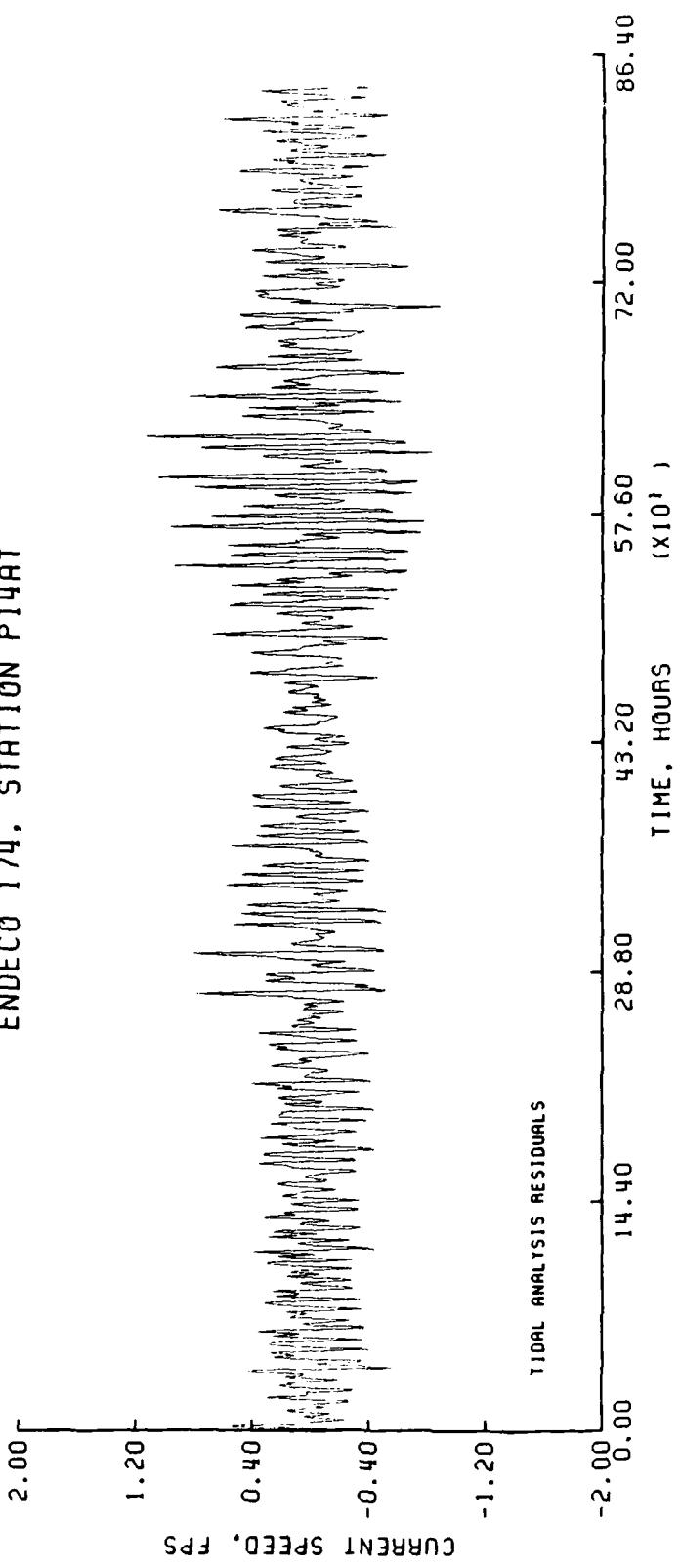
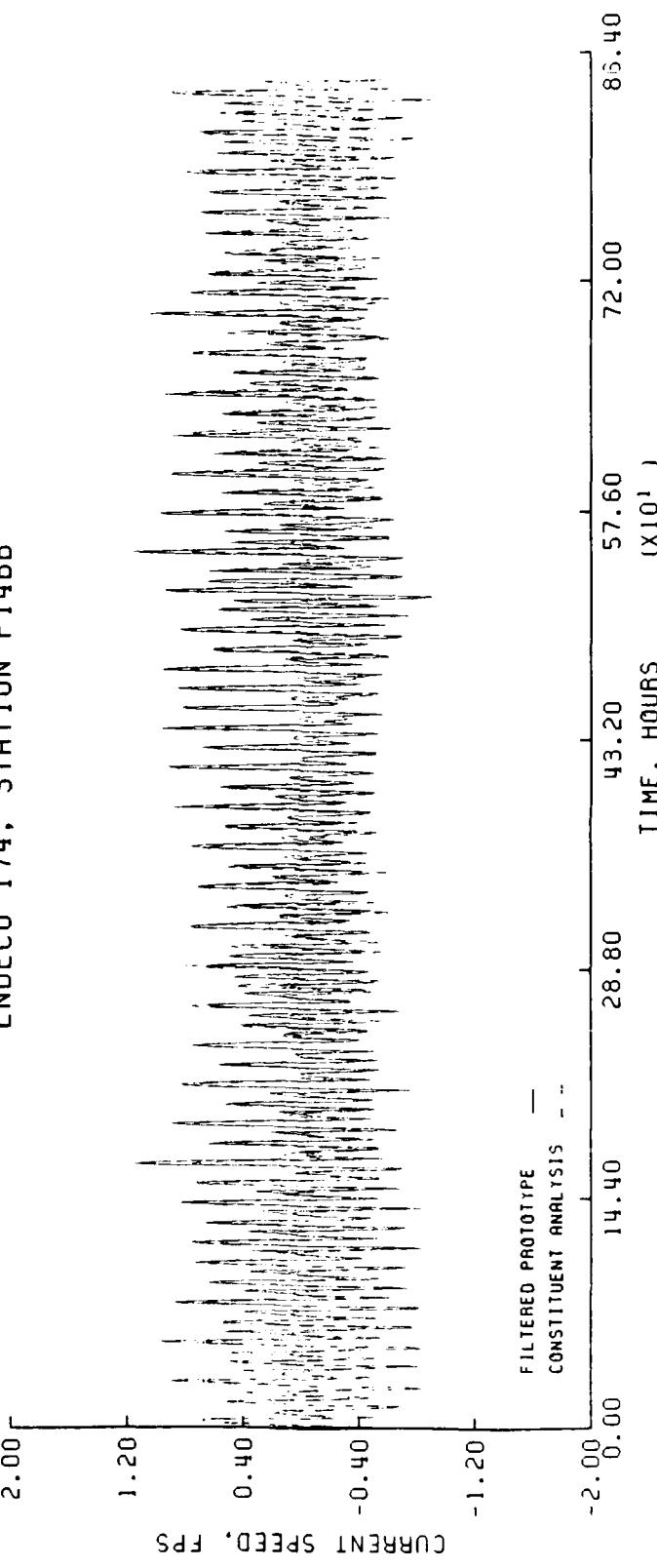


PLATE 88

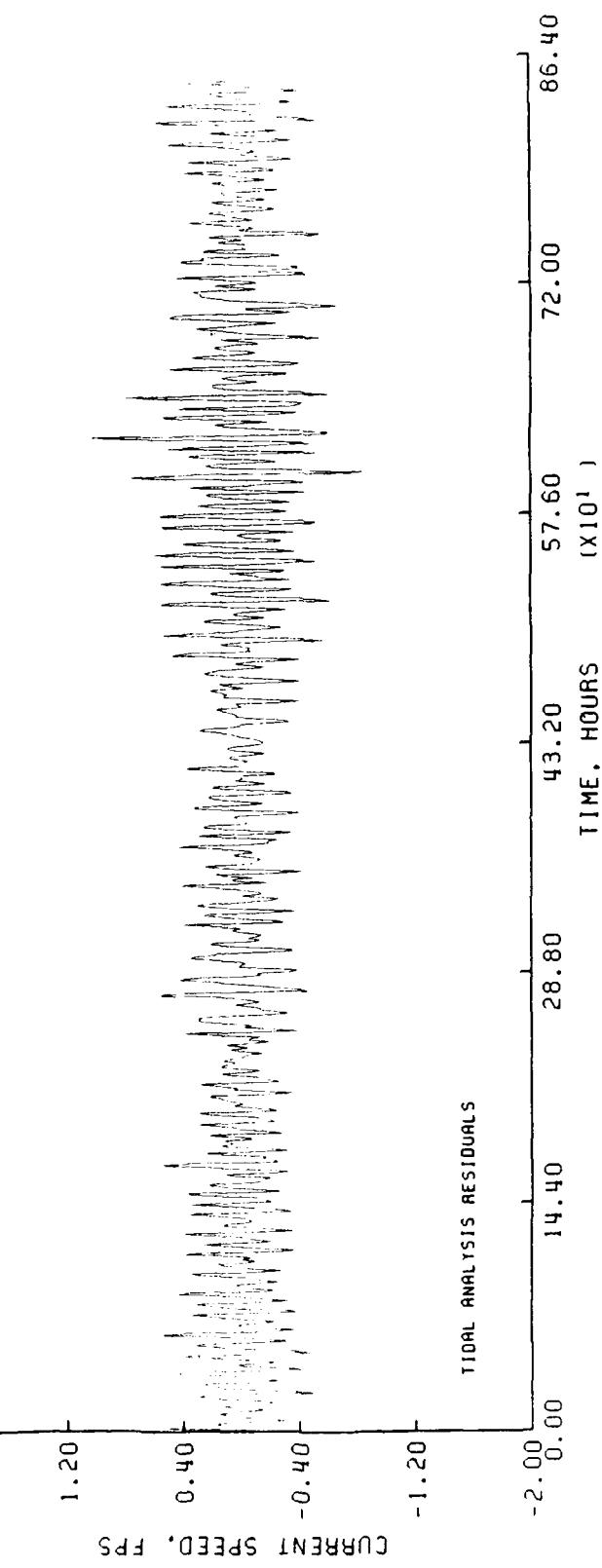
TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PIYAT



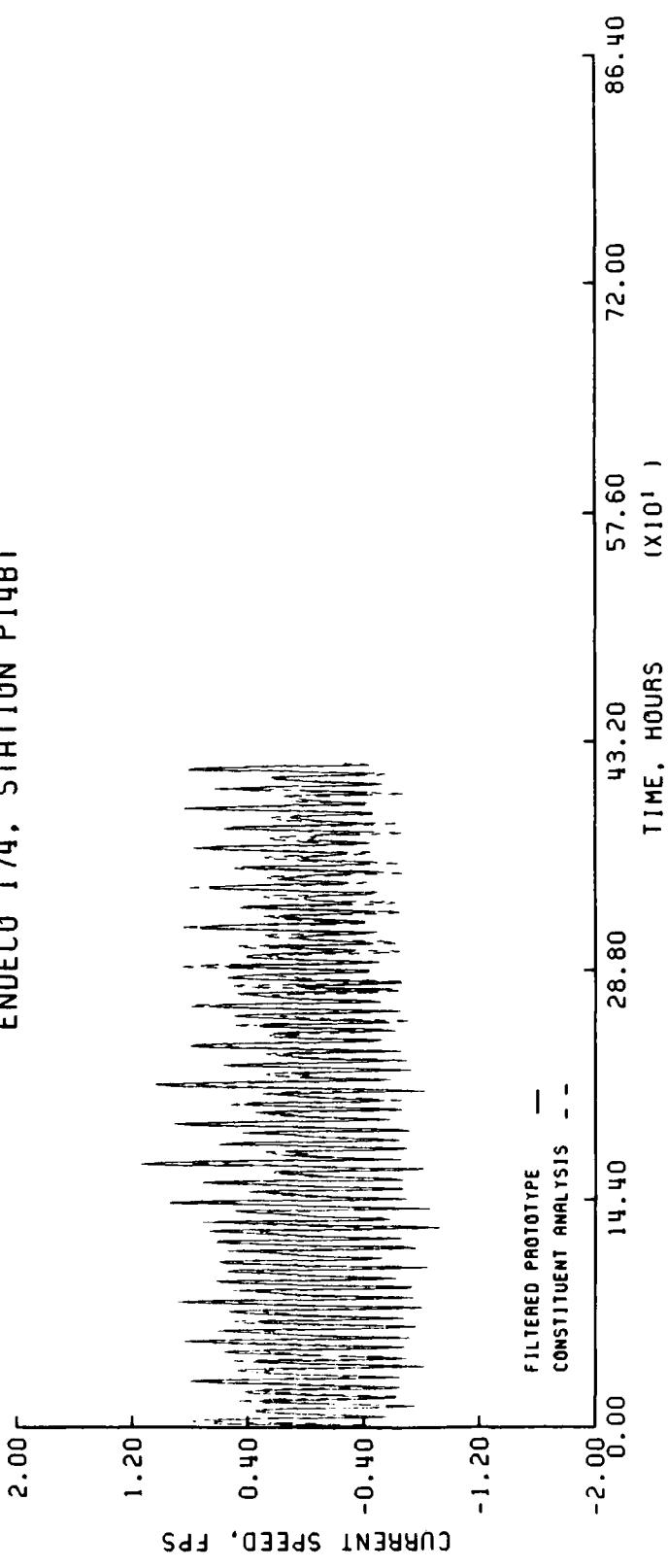
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PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P14BB



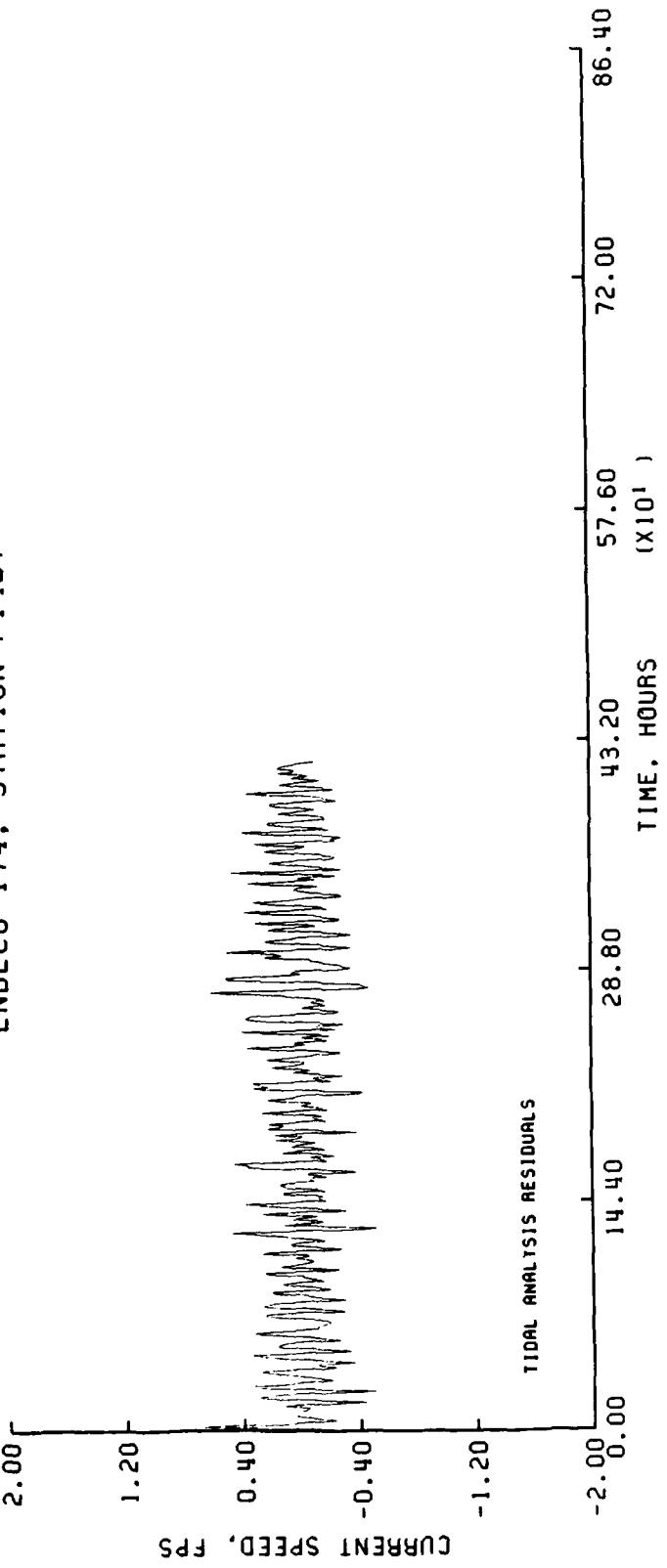
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PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PI4BB



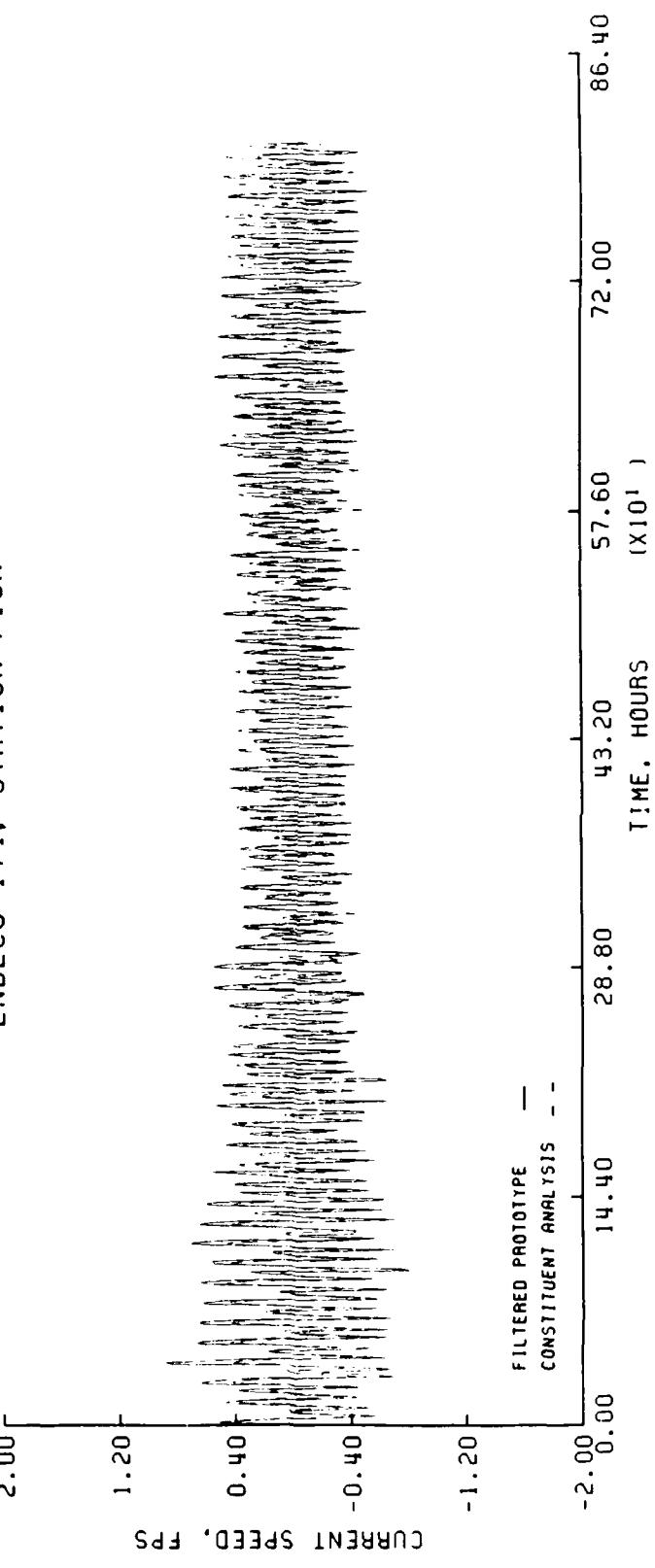
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PONCE DE LEON INET PROJECT  
ENDECO 174, STATION PI4BT



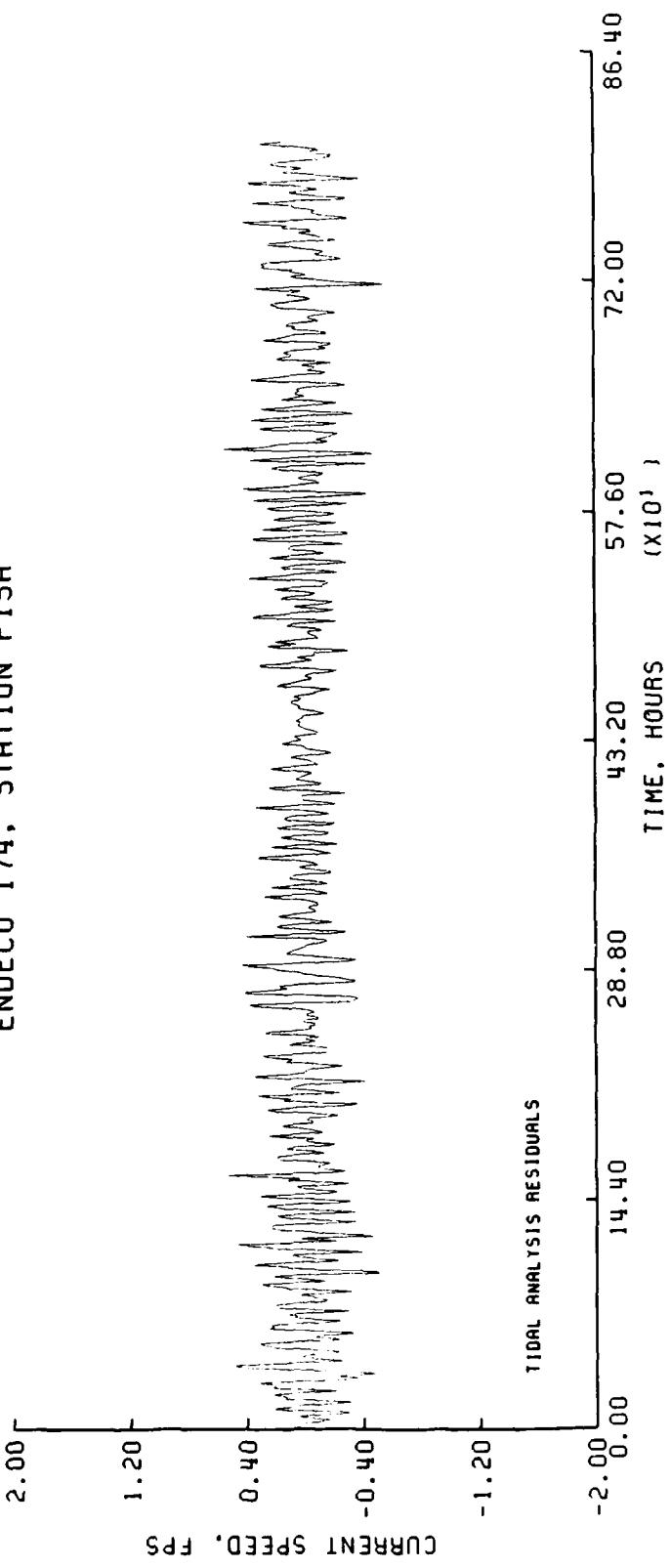
TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INET PROJECT  
ENDECO 174, STATION PI4BT



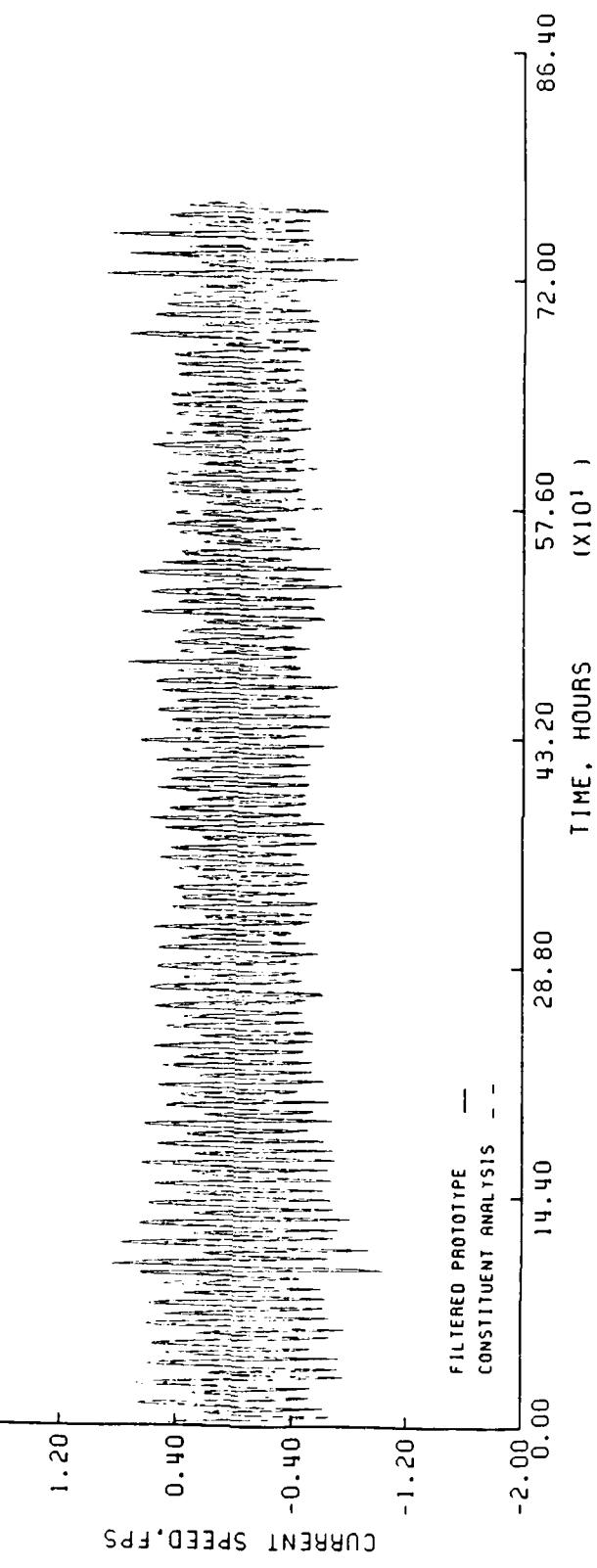
TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P15A



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P15A



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P15B



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P15B

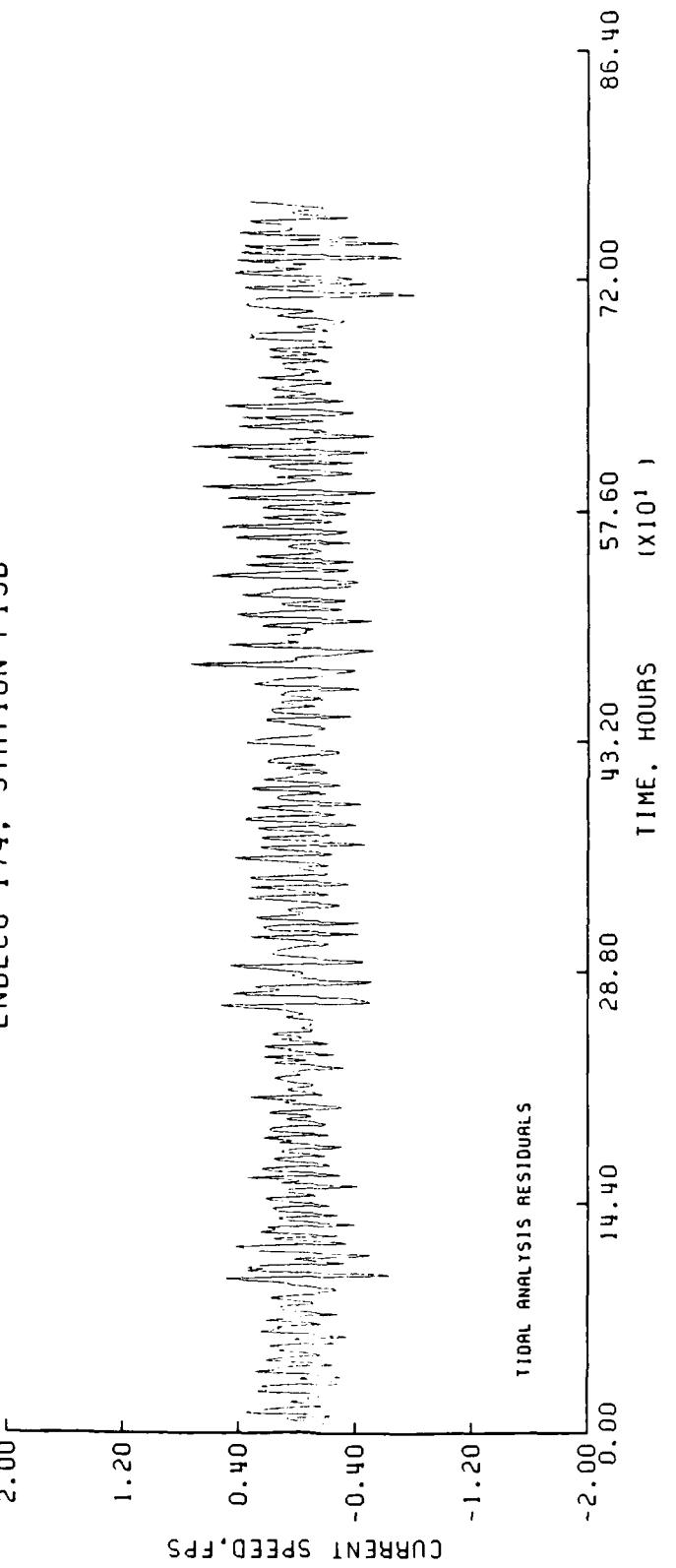
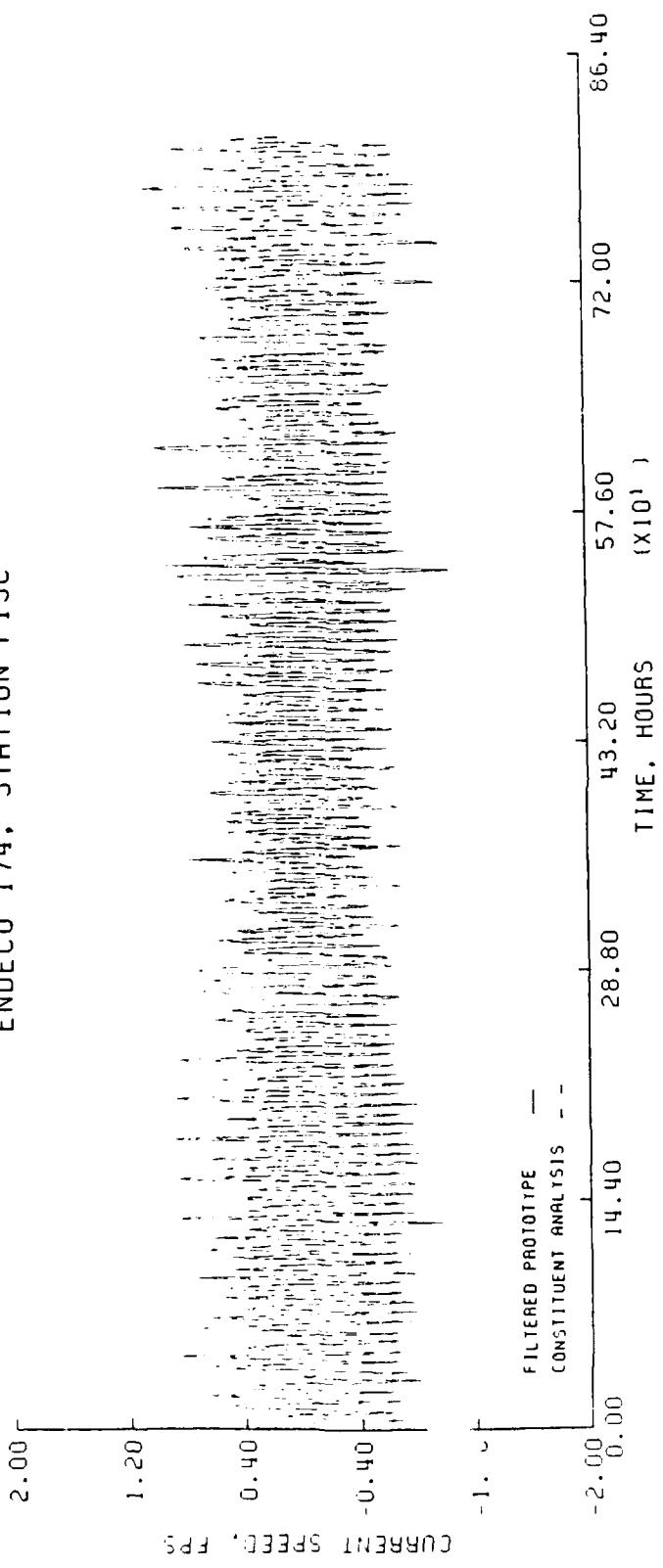
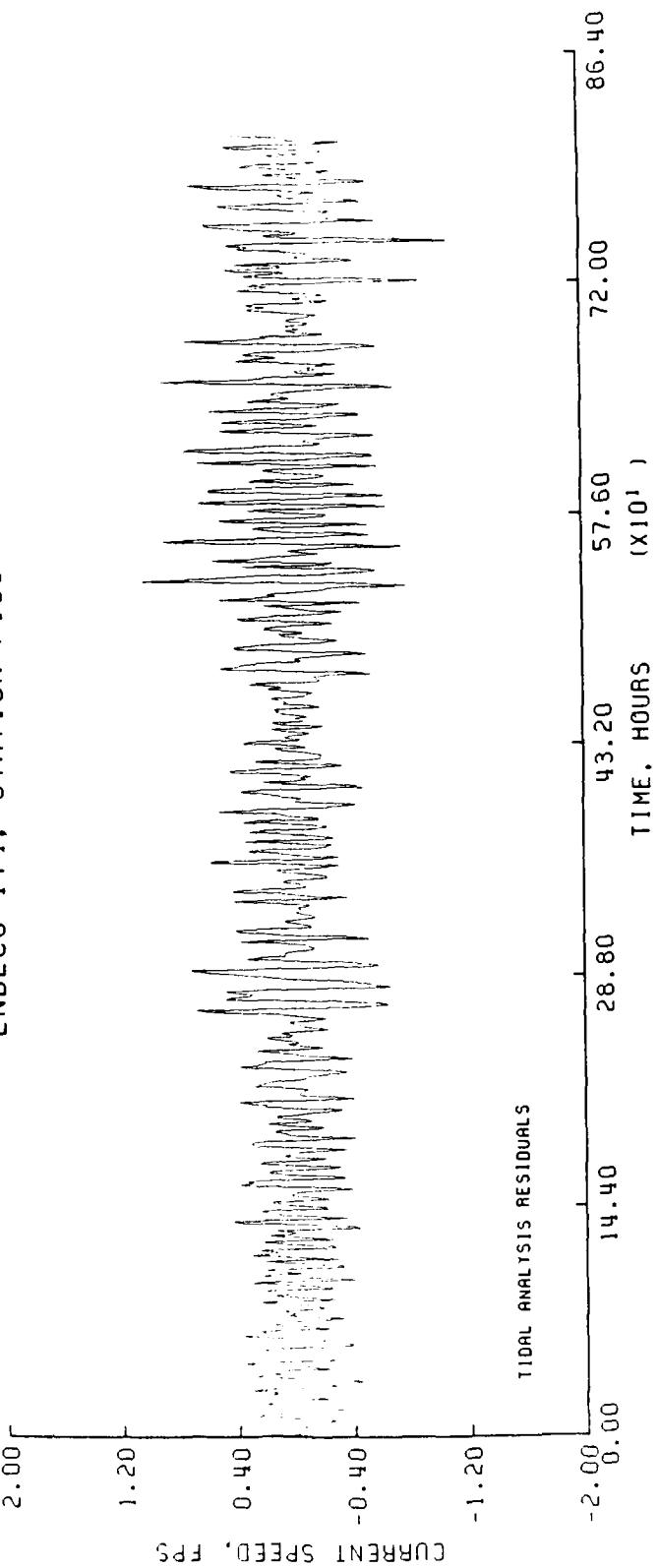


PLATE 97

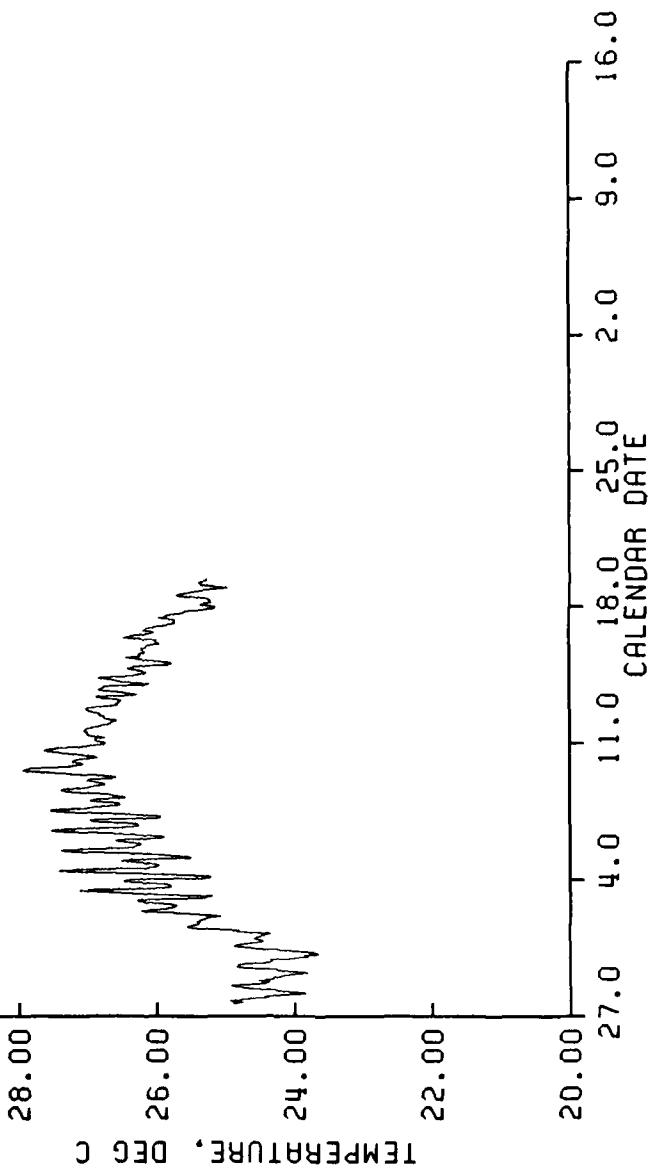
TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P15C



TIDAL HARMONIC ANALYSIS  
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P15C



PONCE DE LEON INLET PROJECT  
TDR-2 STATION PI159  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83



PONCE DE LEON INLET PROJECT  
TDR-2 STATION PI152  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83

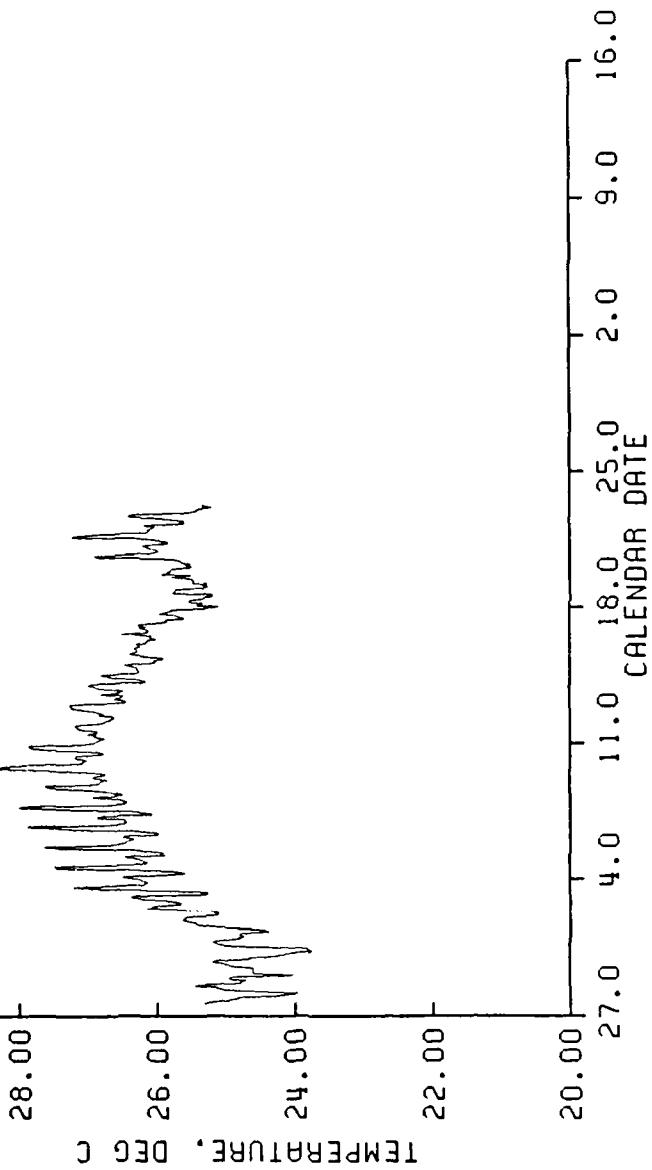
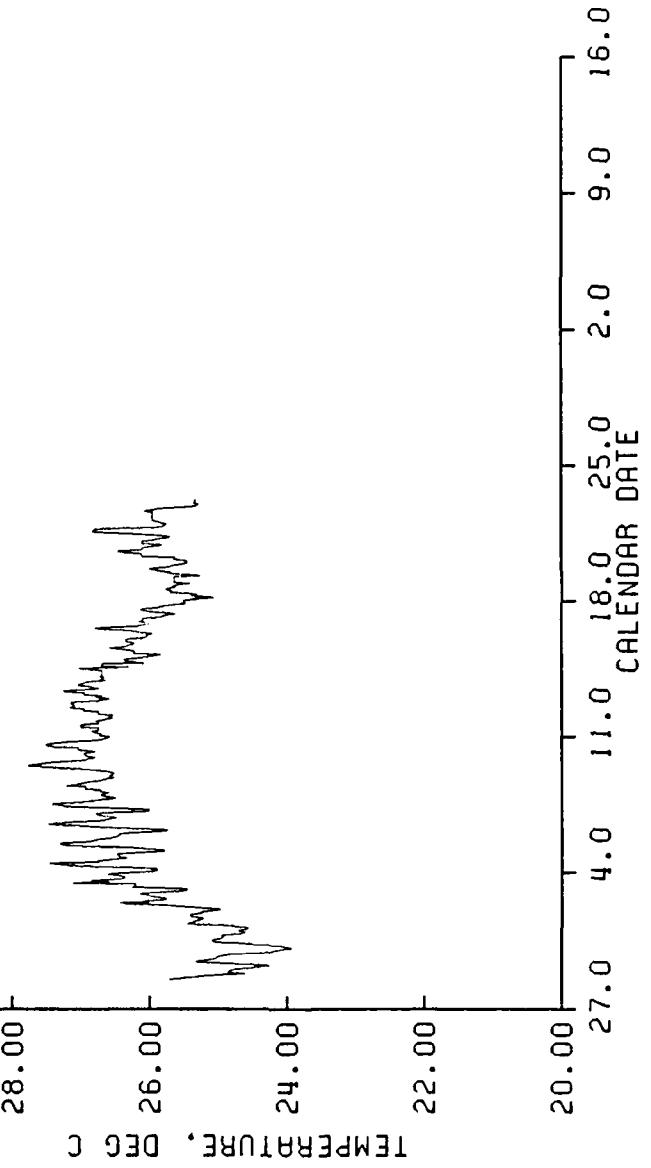
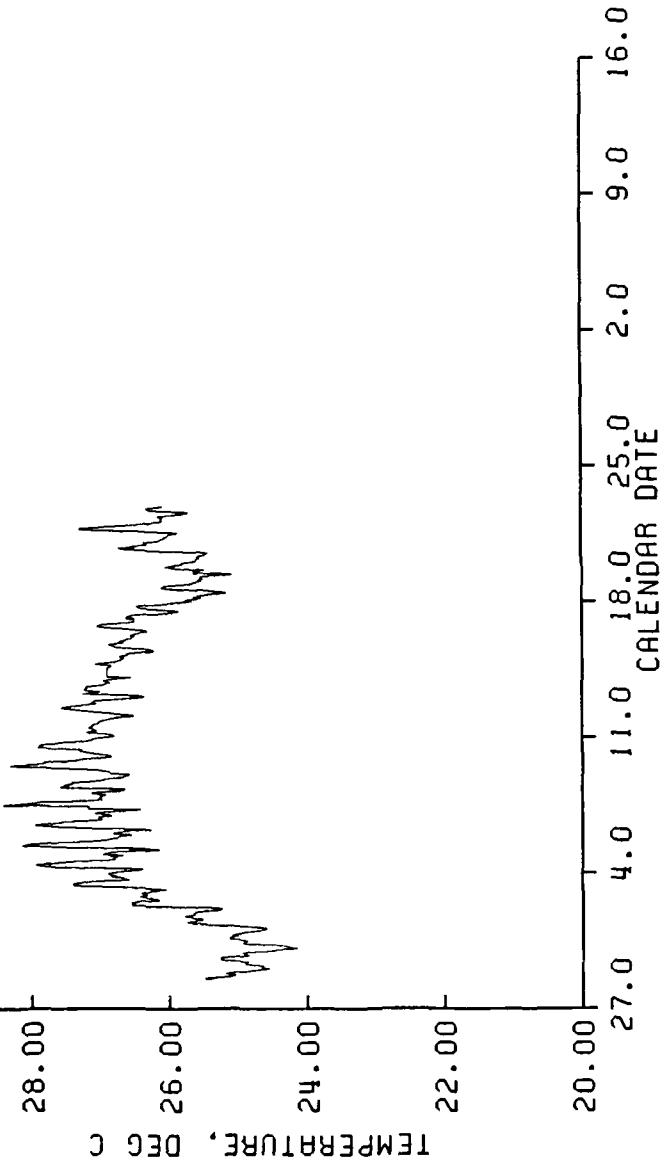


PLATE 101

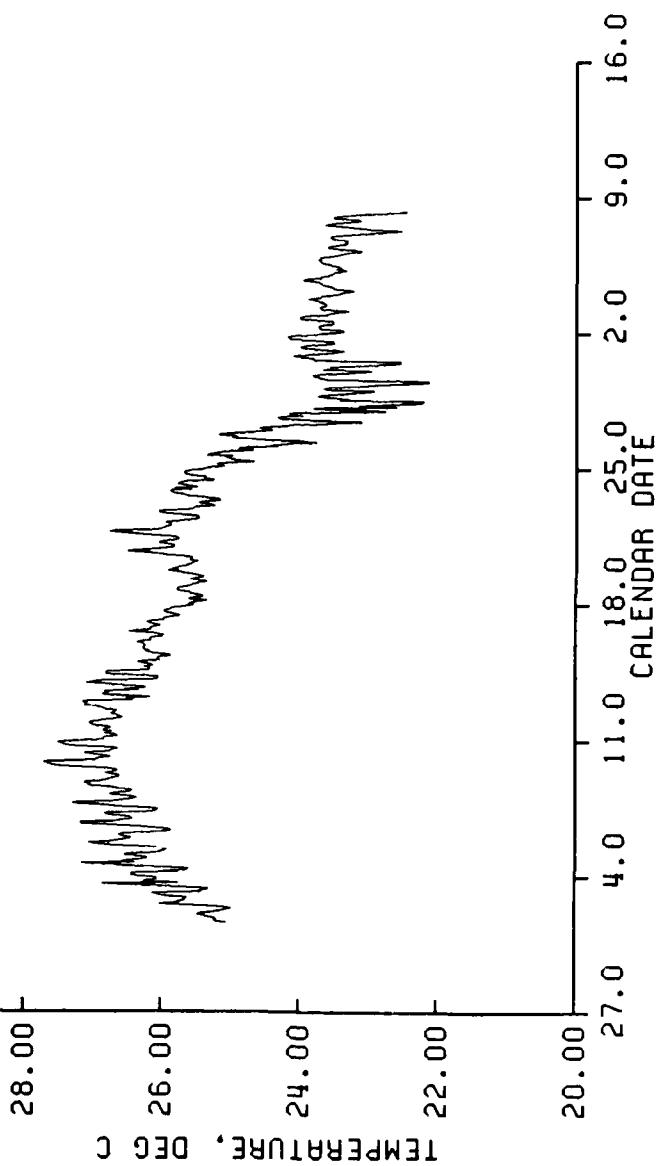
PONCE DE LEON INLET PROJECT  
TOR-2 STATION PI154  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83



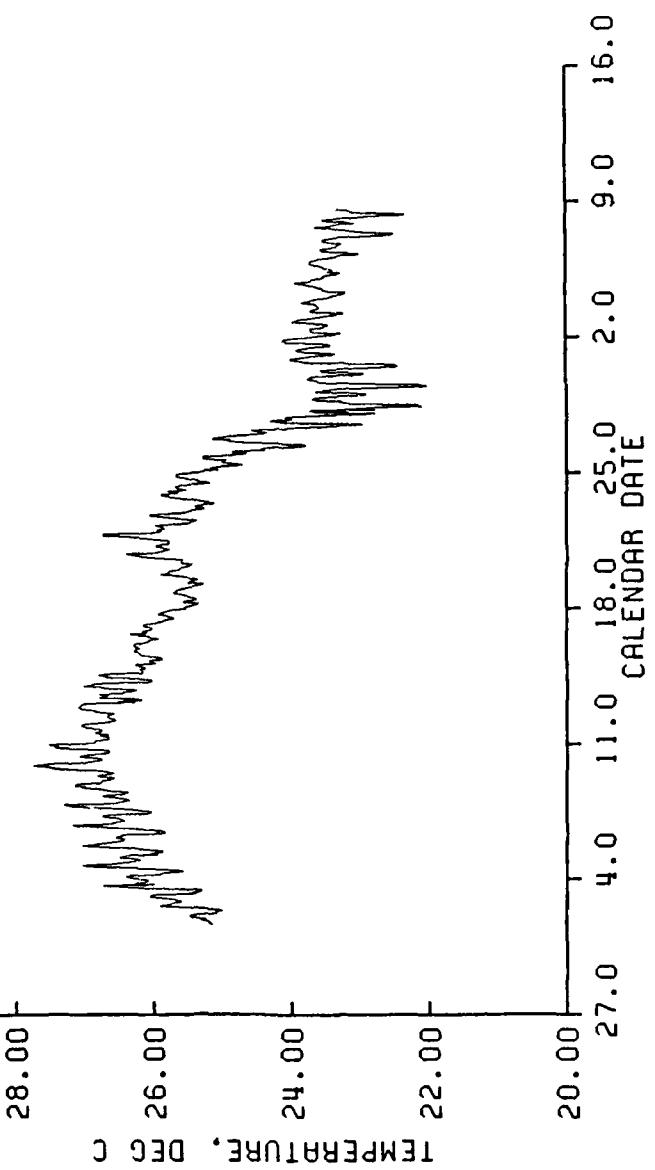
PONCE DE LEON INLET PROJECT  
TDR-2, STATION PI158  
EDITED 1 HOUR AVERAGES, SEPT TO NOV '83



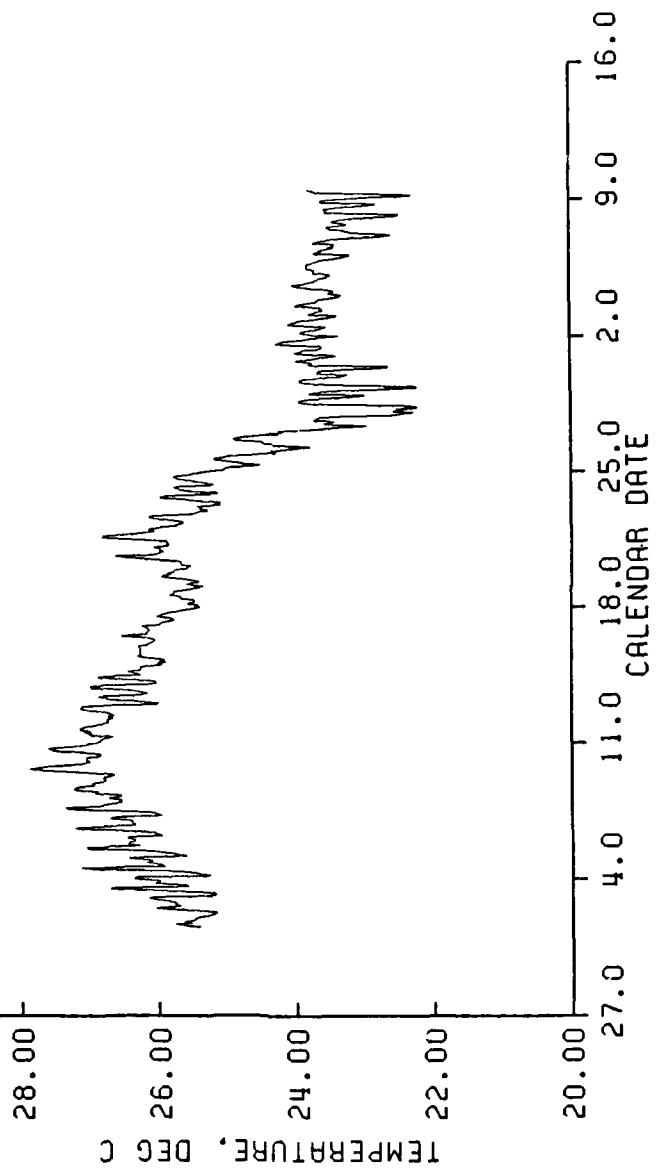
PONCE DE LEON INLET PROJECT  
ENDECO 170, STATION P12AB  
RAW 1 HOUR AVERAGES, SEPT 10 NOV '83



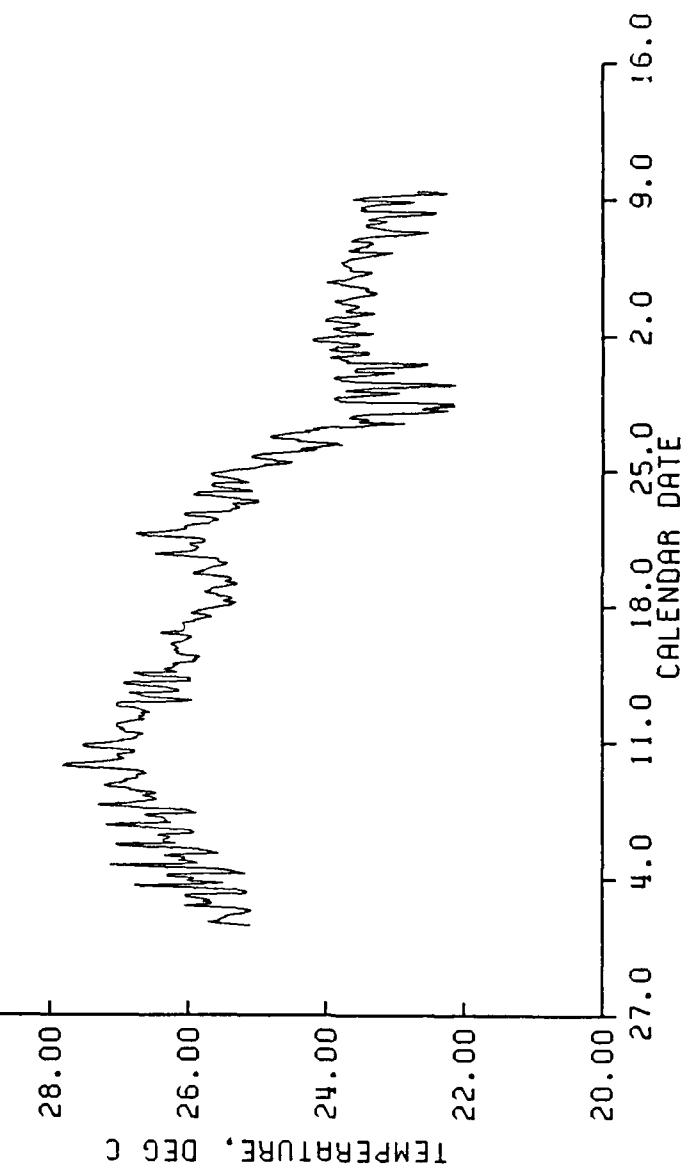
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P12AT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



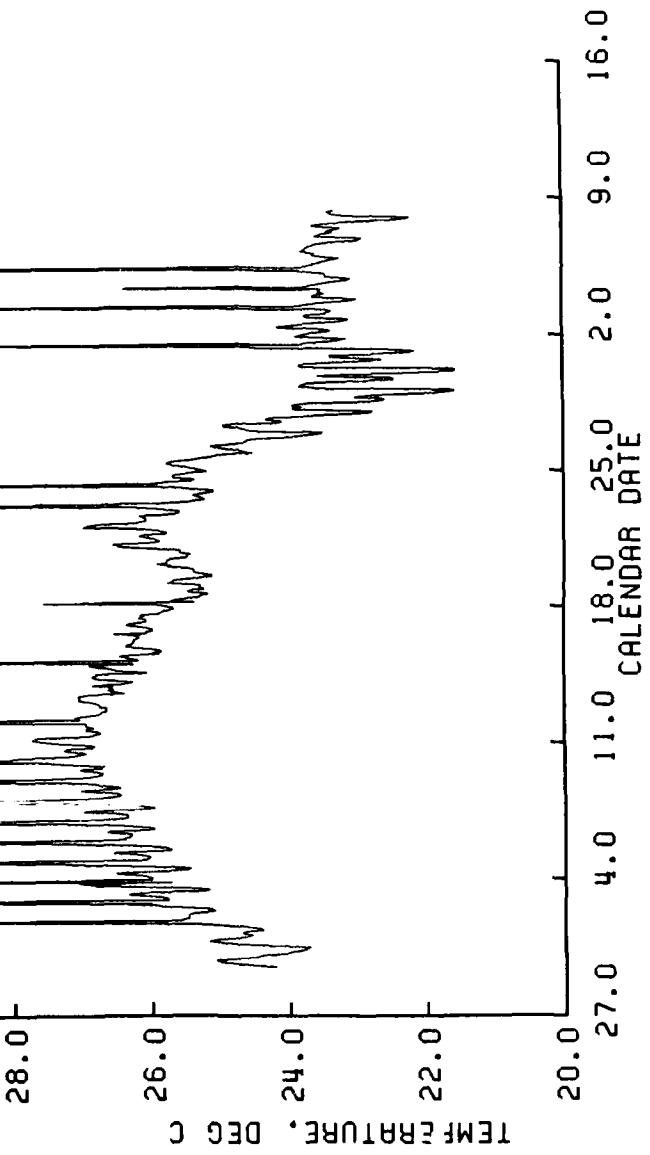
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ENDECO 174, STATION P12BB  
RAW 1 HOUR AVERAGES, SEPT 10 NOV '83



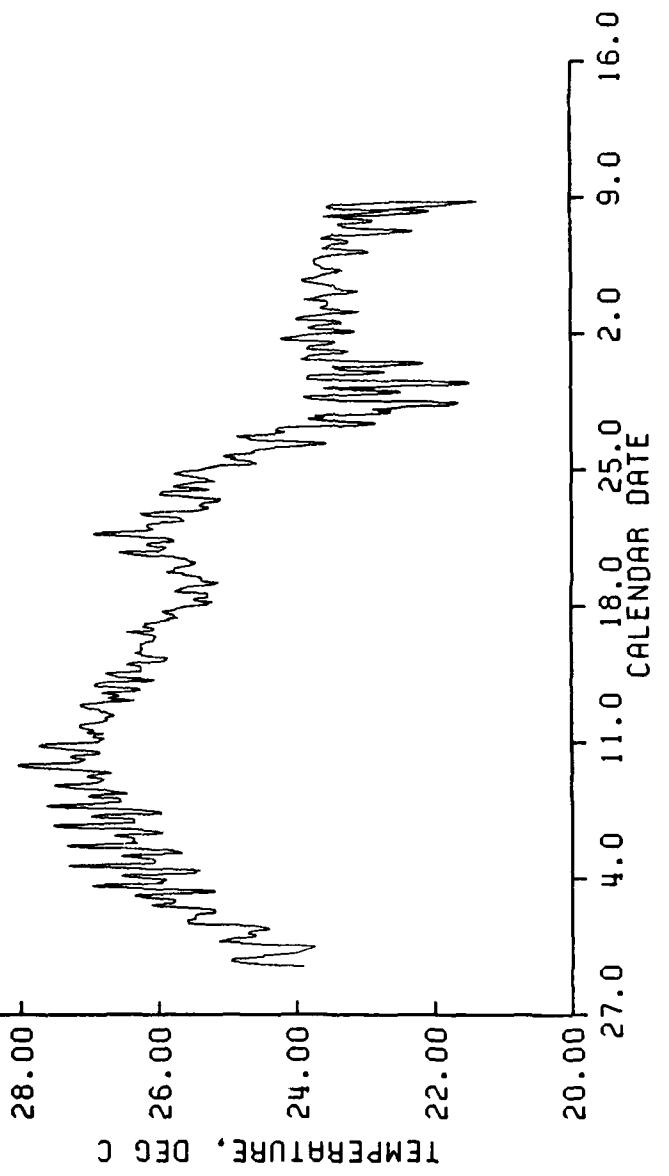
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ENDECO 174, STATION P12BT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



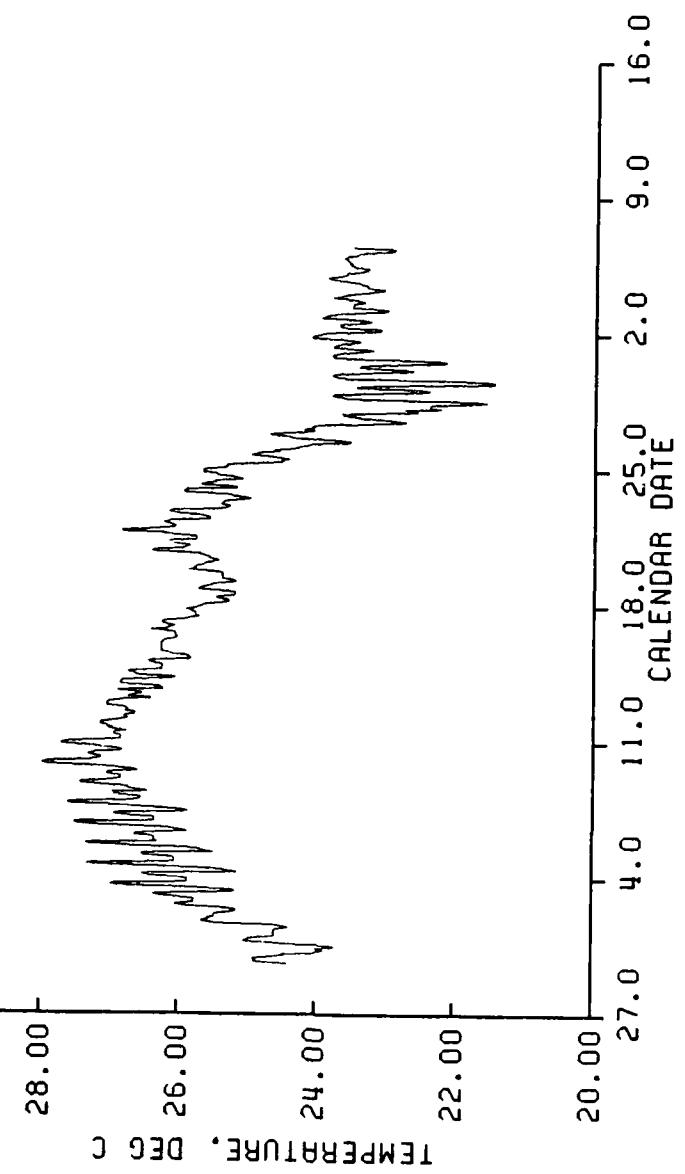
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ENDECO 174, STATION PI3A  
RAW 1 HOUR AVERAGES  
10 NOV 83



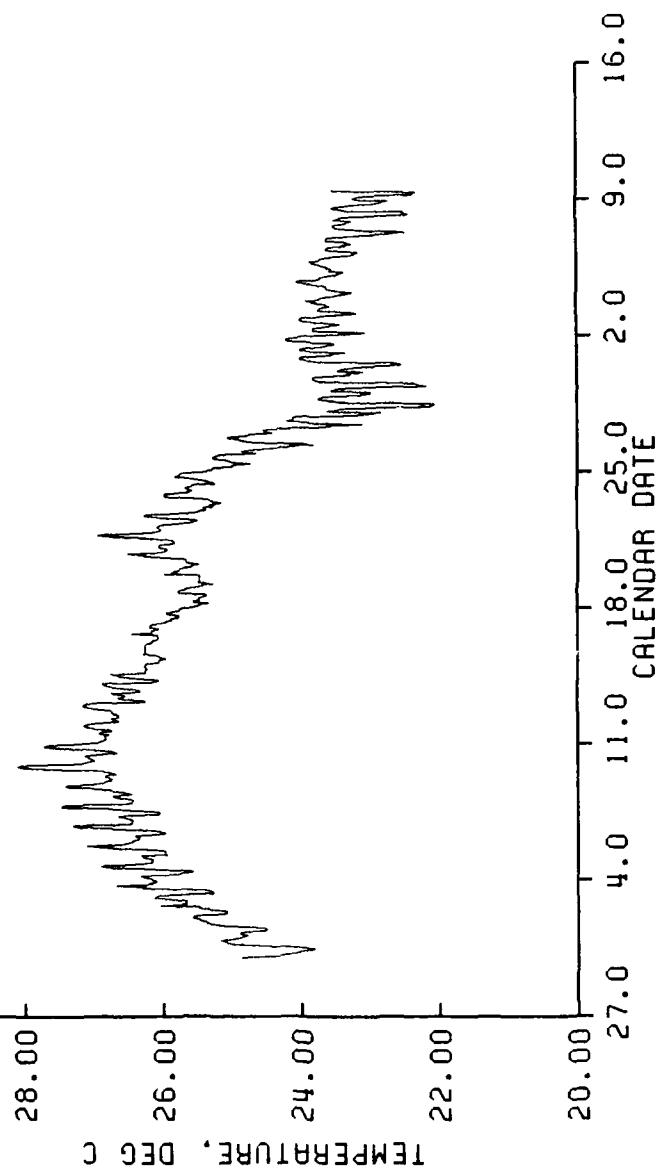
PONCE DE LEON INLET PROJECT  
ENDEC 0174, STATION PI3B  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



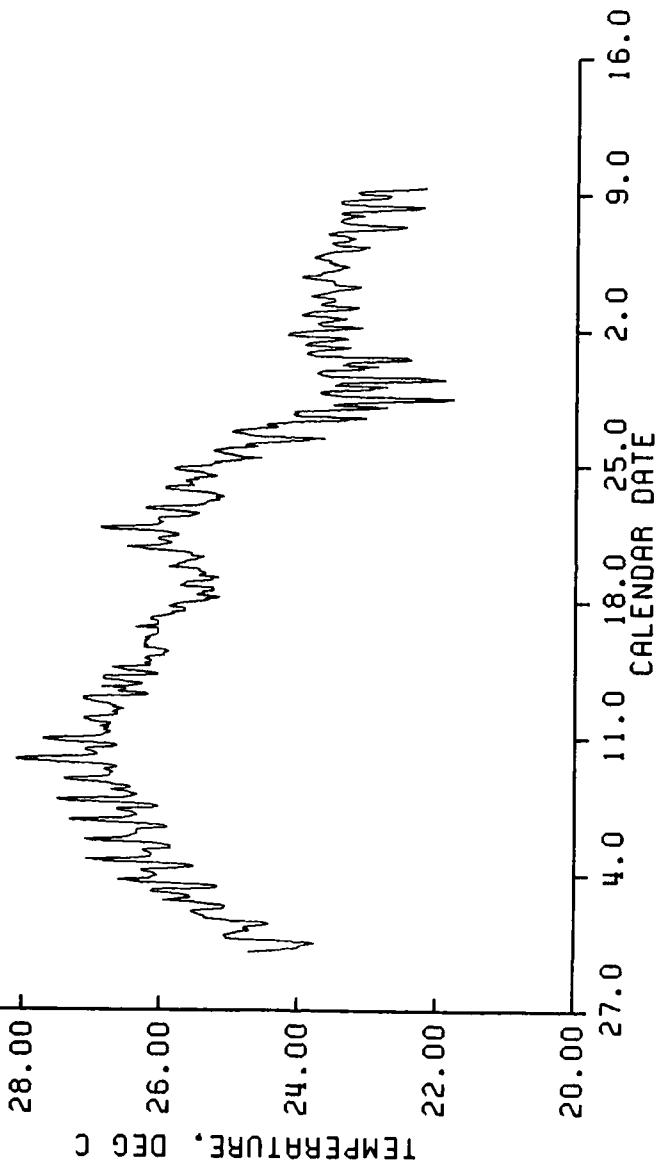
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PI3C  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



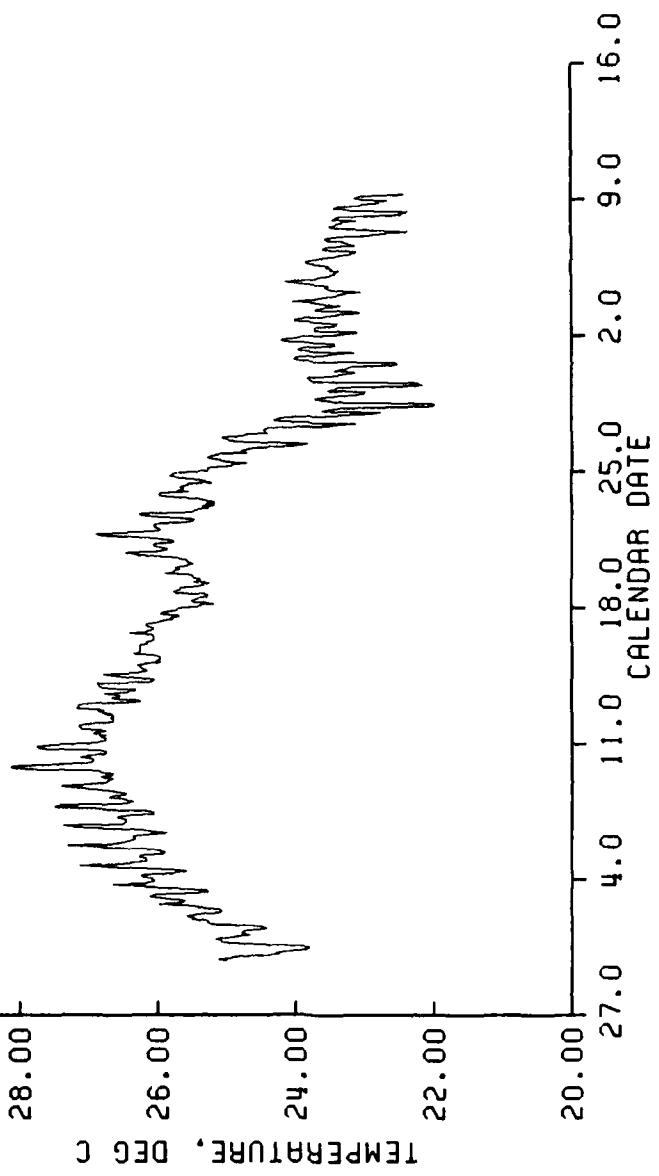
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ENDECO 174, STATION PI4AB  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



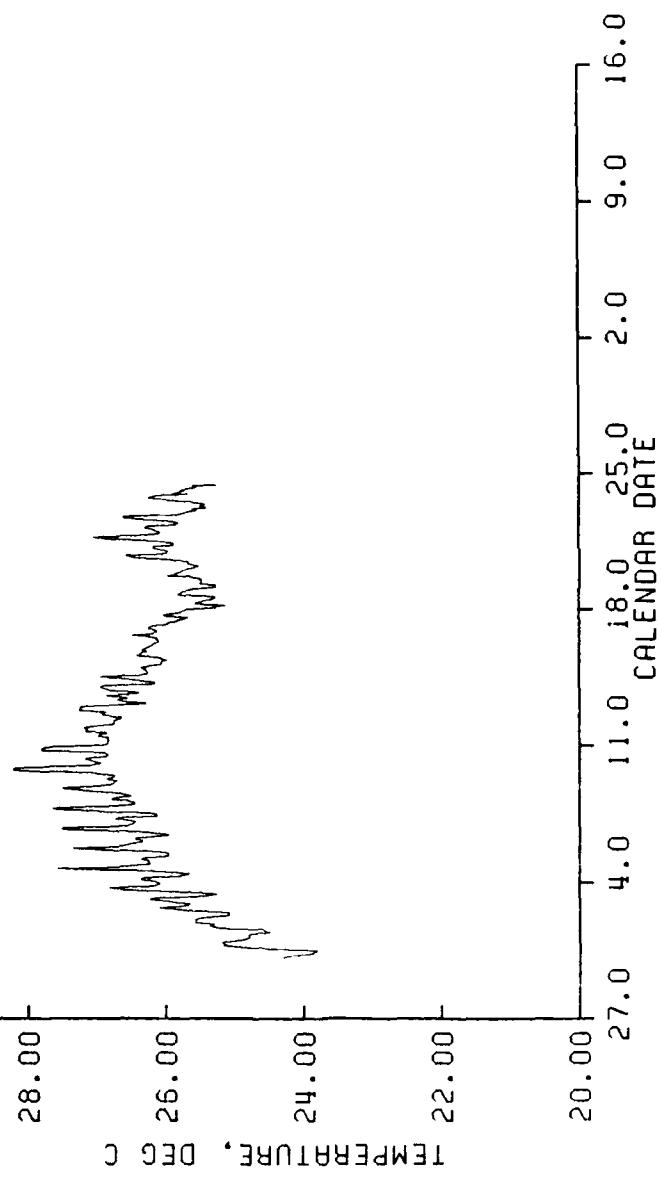
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ENDECO 174, STATION PIYAT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



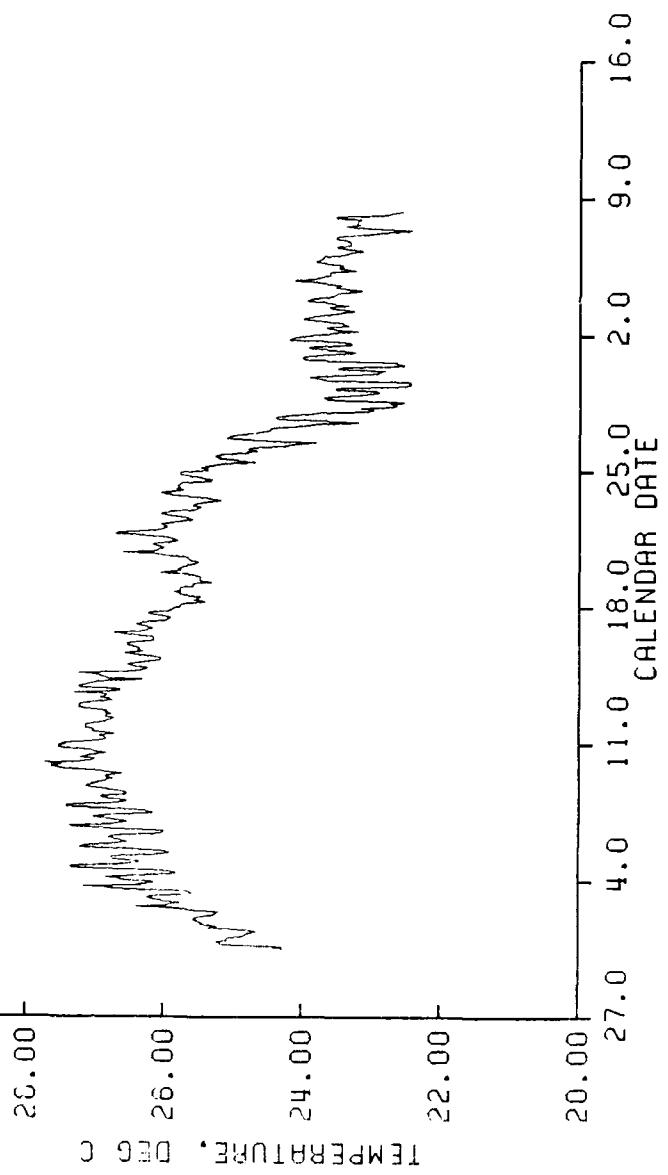
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ENDECO 174, STATION PI4BB  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



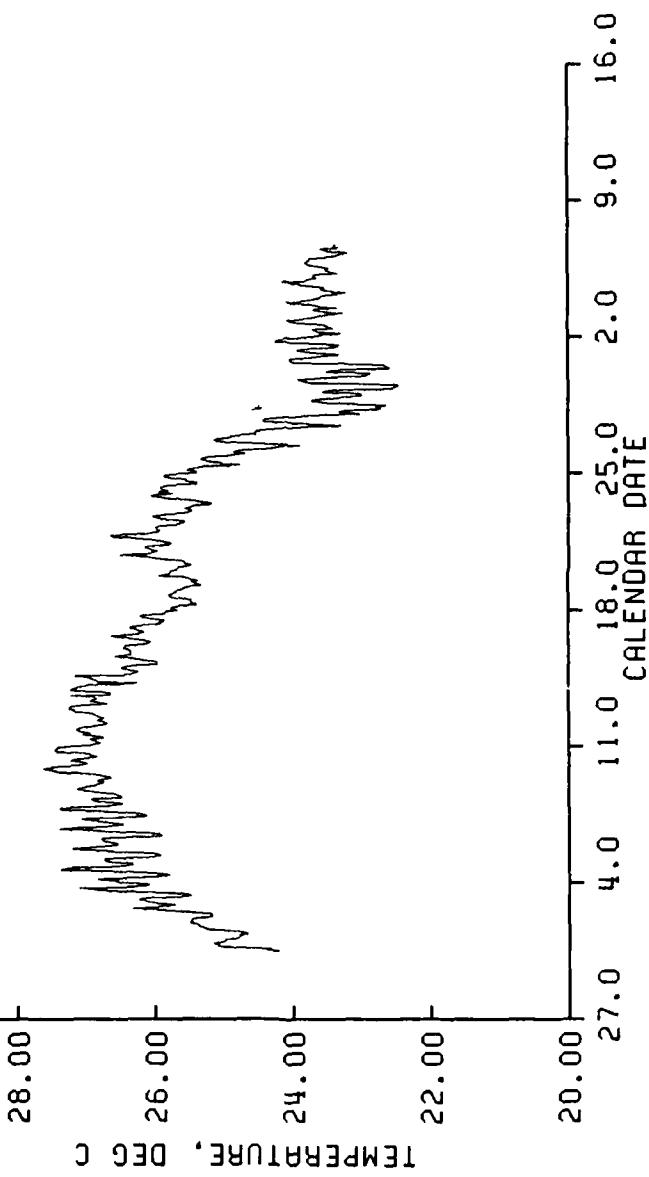
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ENDECO 174, STATION PI4BT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



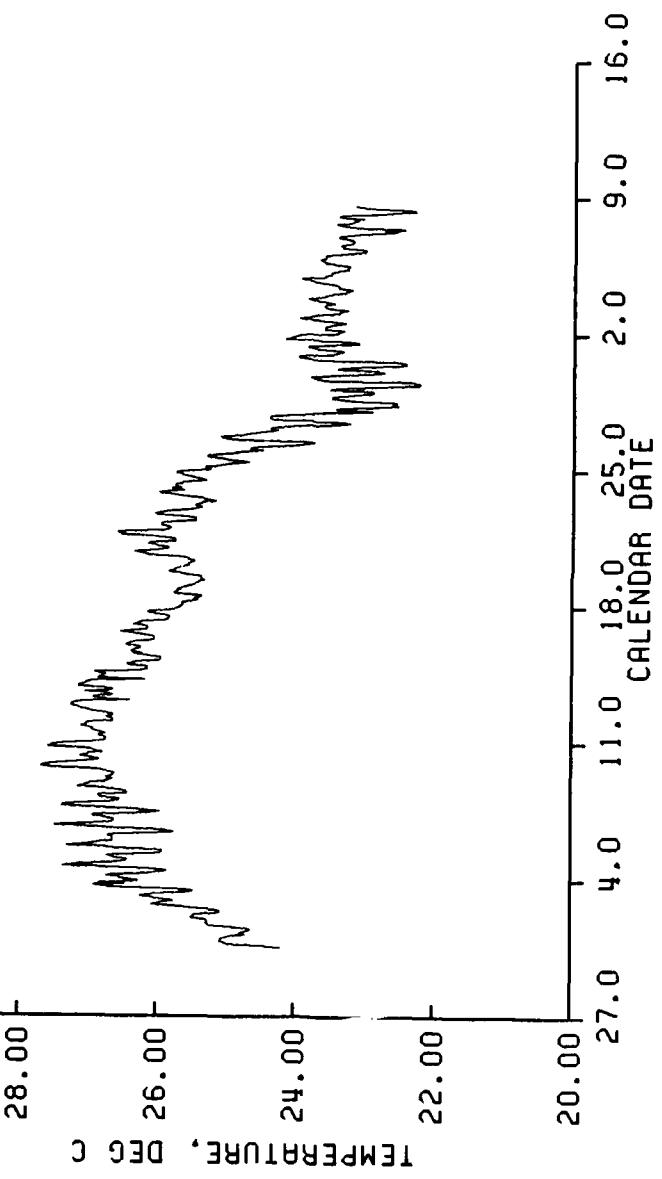
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ENDECO 174, STATION P15A  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



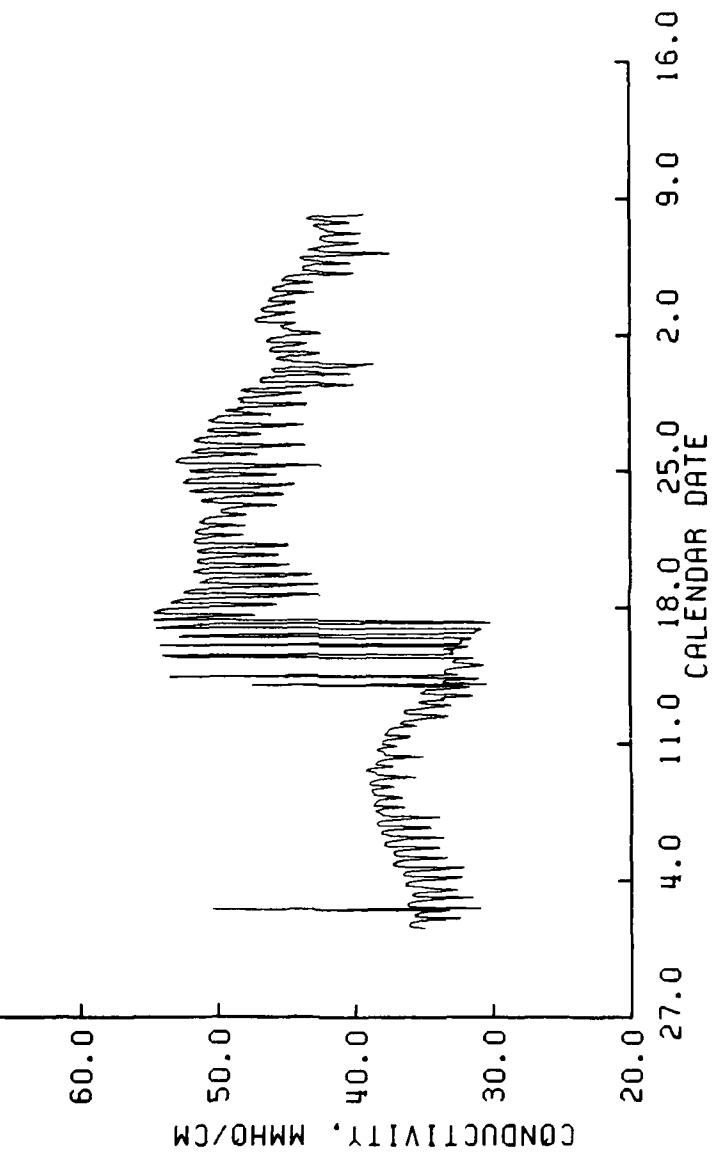
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P15B  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



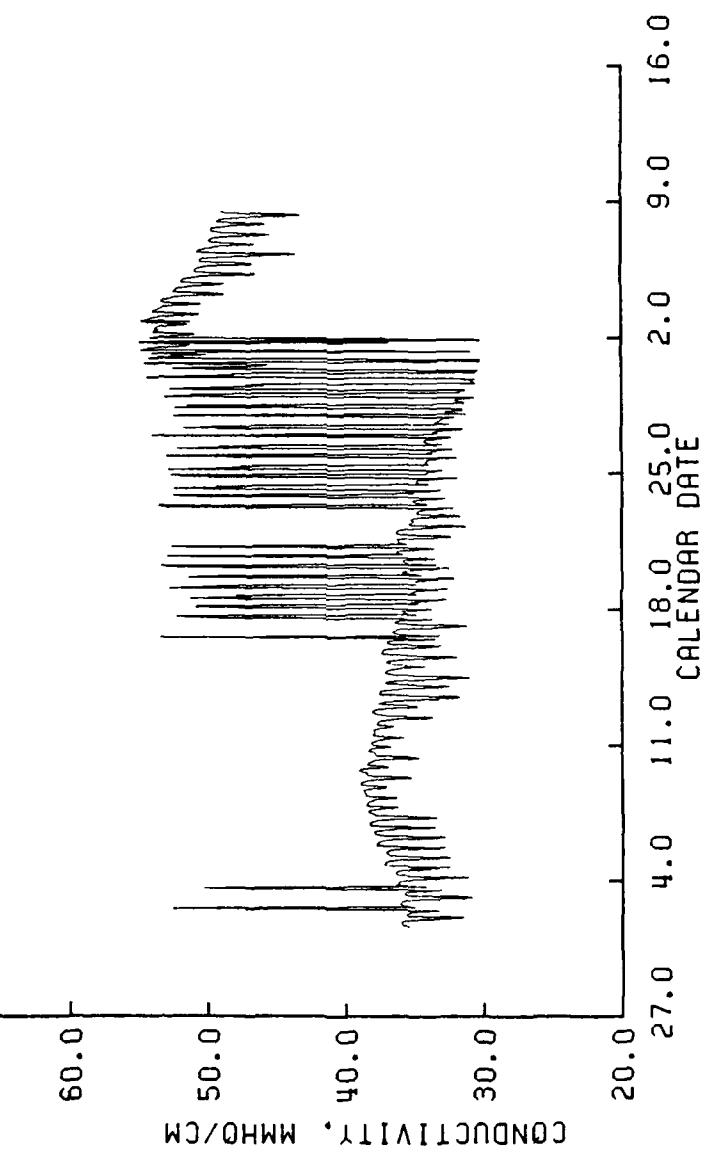
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ENDECO 174, STATION P15C  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



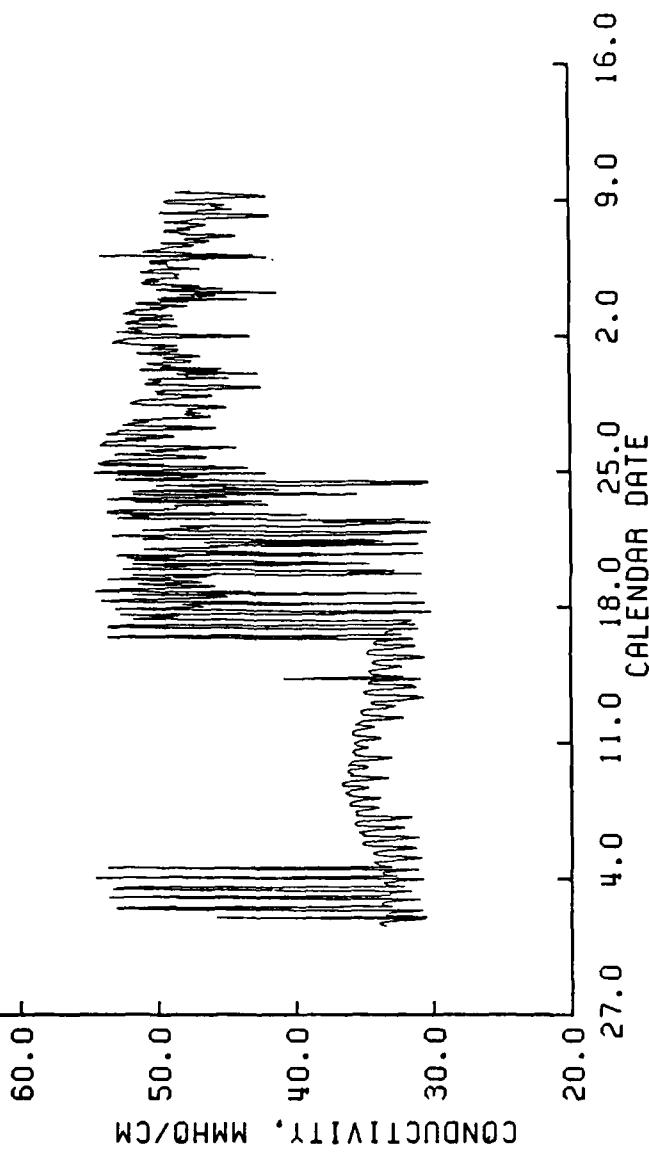
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ENDECO 174, STATION P12AB  
RAW 1 HOUR AVERAGES, SEPT 10 NOV '83



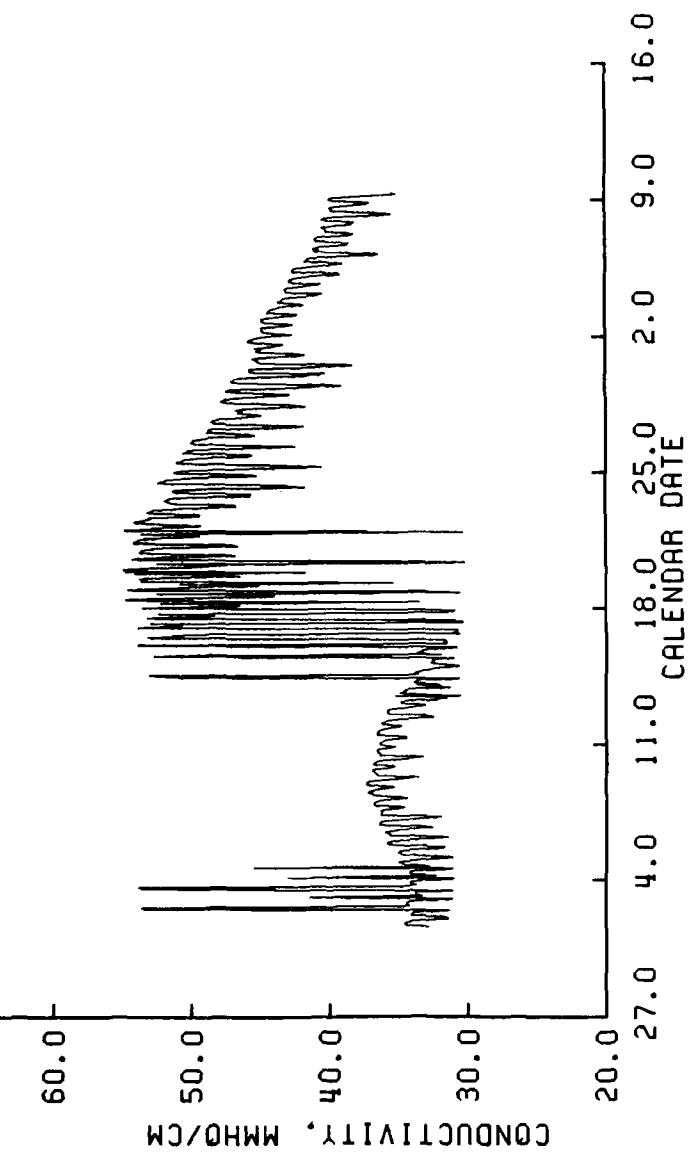
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ENDEC0 174, STATION P12AT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



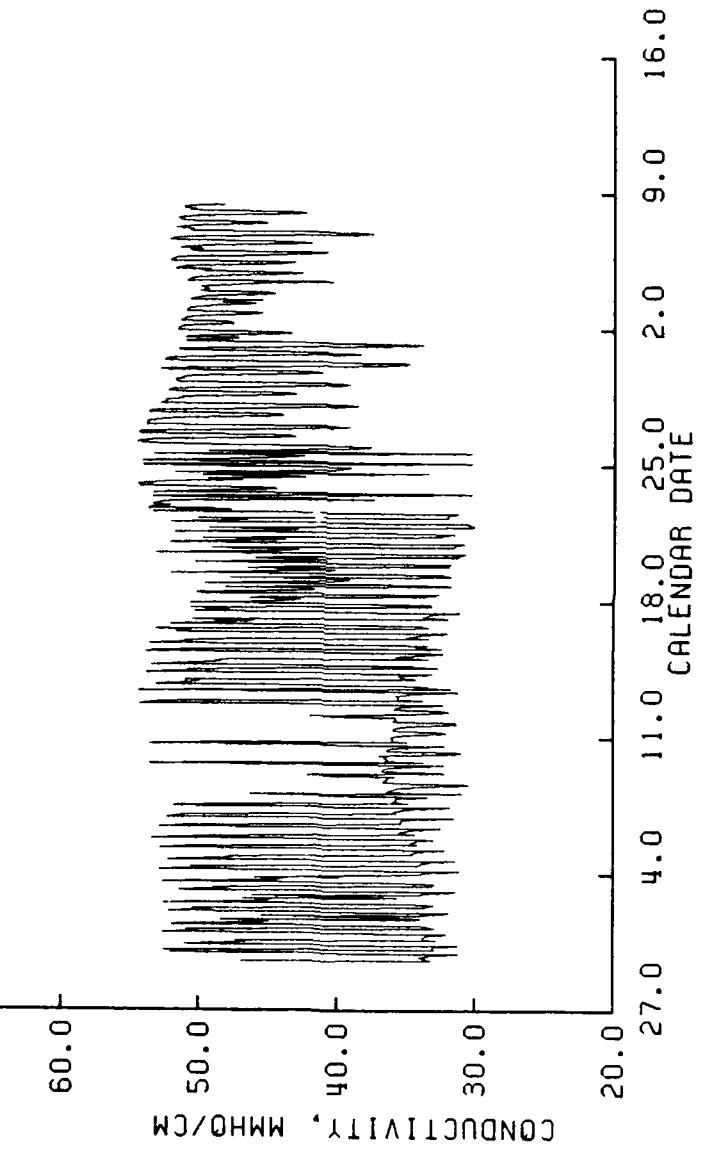
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ENDECO 174, STATION P12BB  
RAW 1 HOUR AVERAGES, SEPT 10 NOV '83



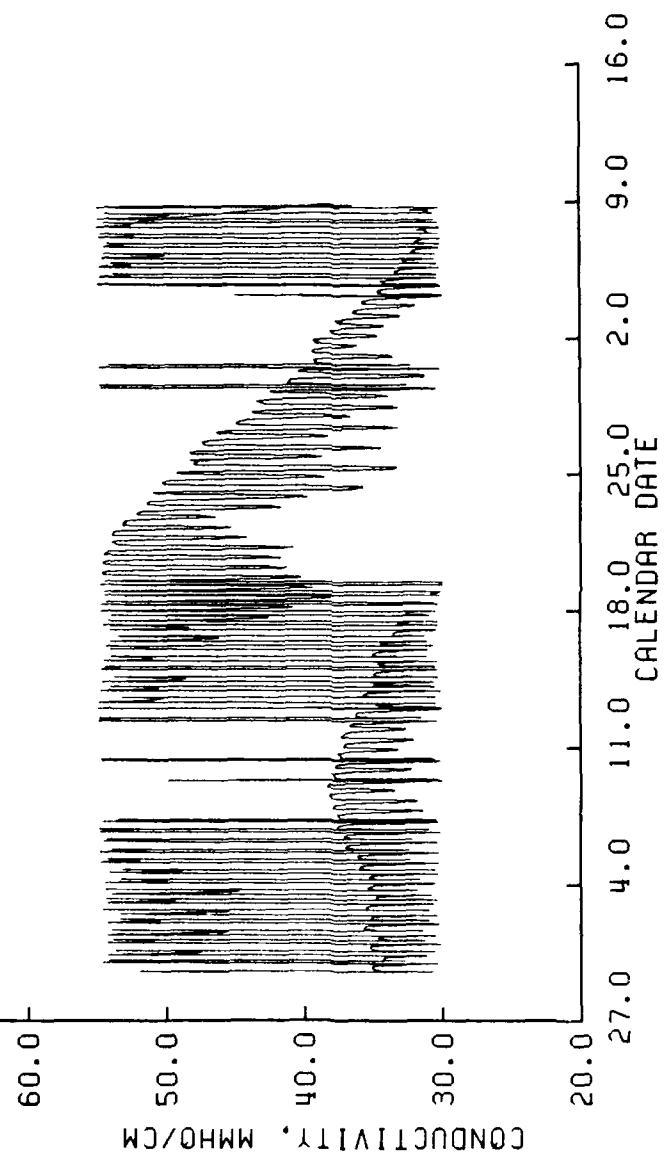
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ENDECO 174. STATION PI2BT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



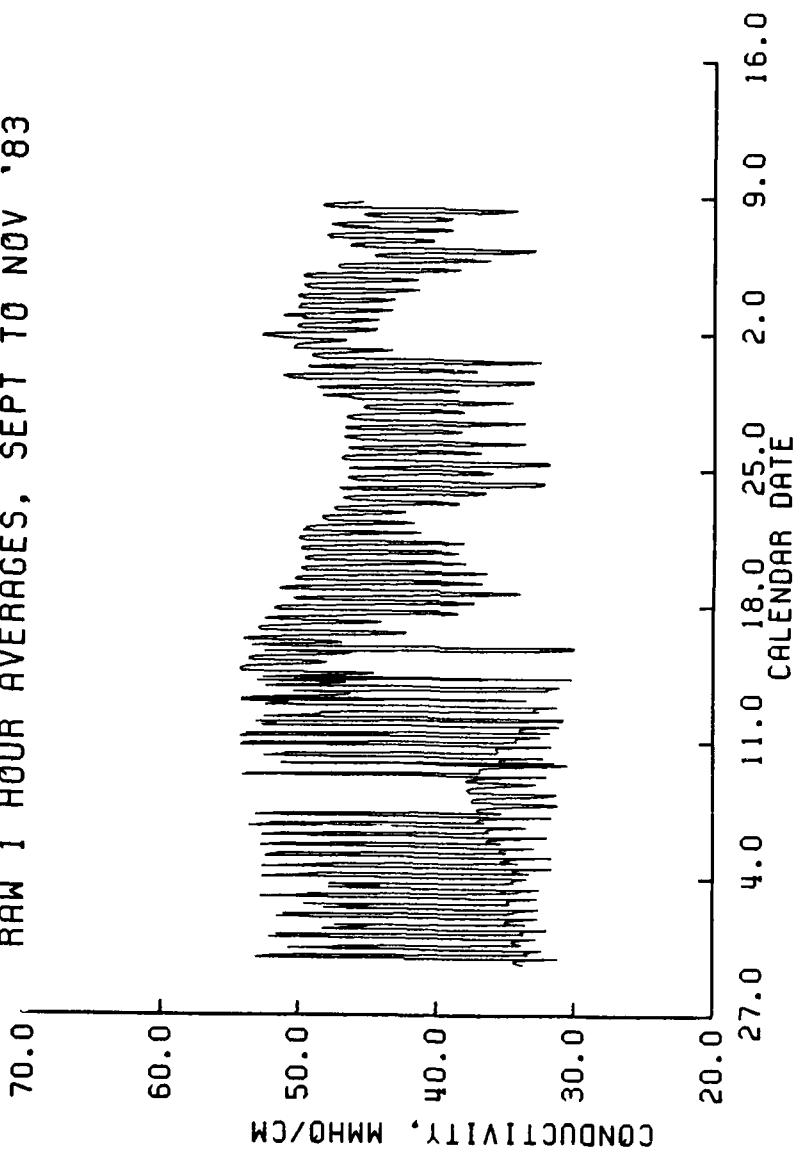
PONCE DE LEON INLET PROJECT  
ENDECO 174. STATION P13A  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



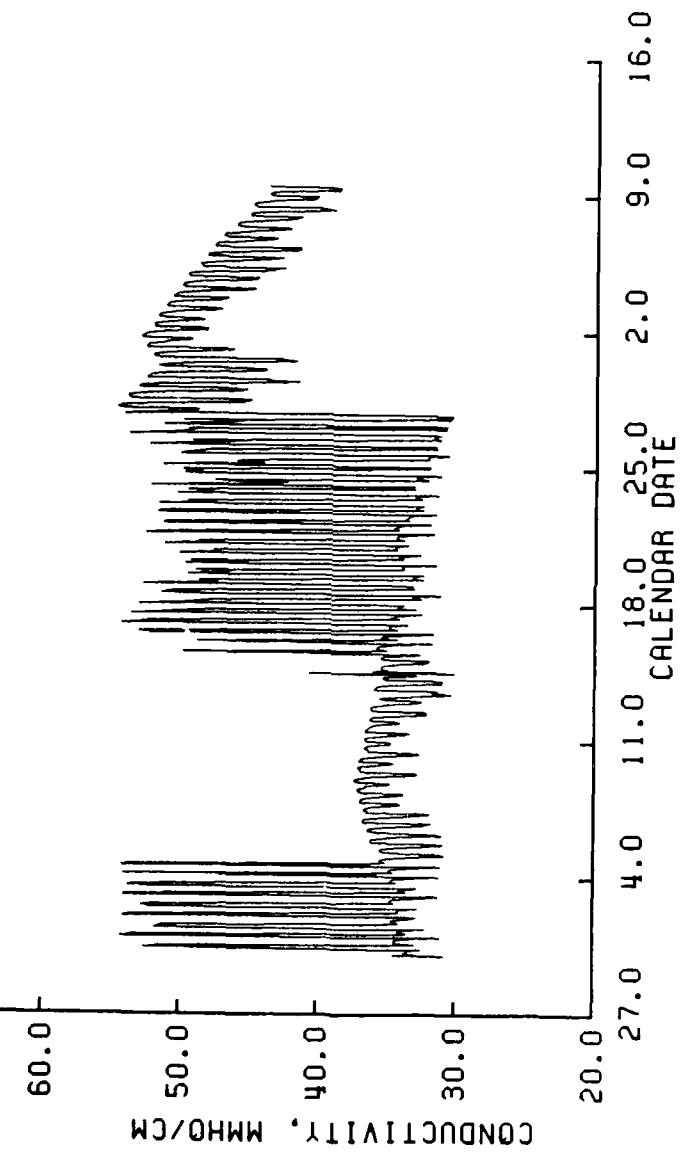
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ENDECO 174, STATION P13B  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



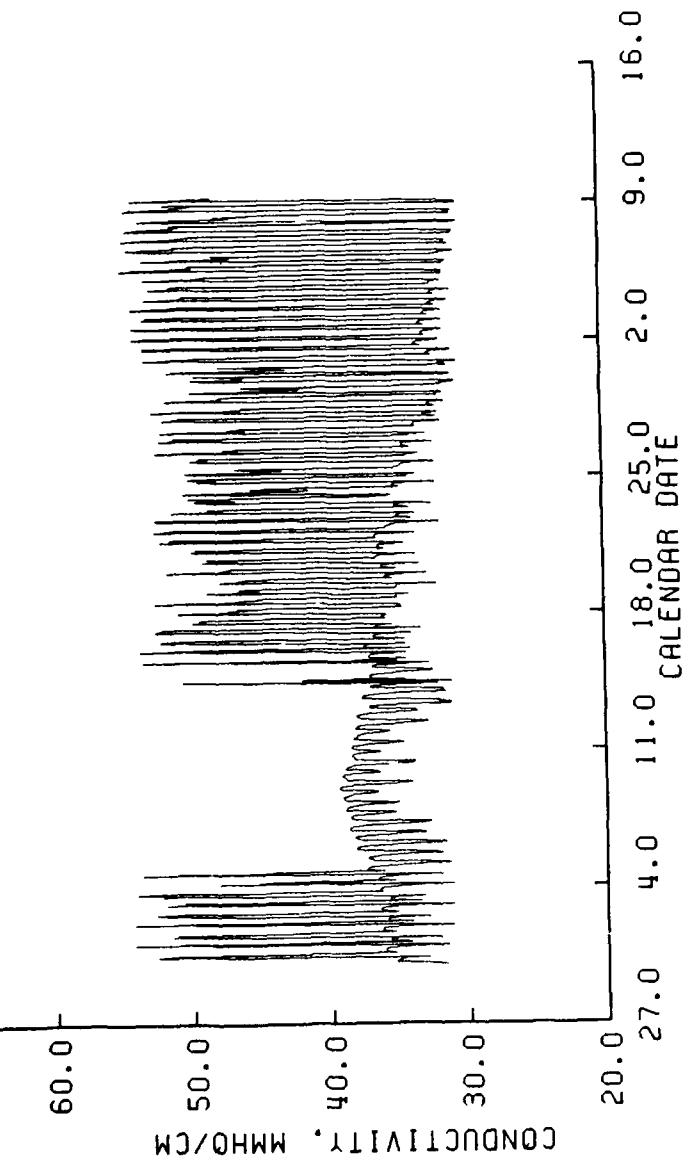
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ENDECO 174, STATION P13C  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



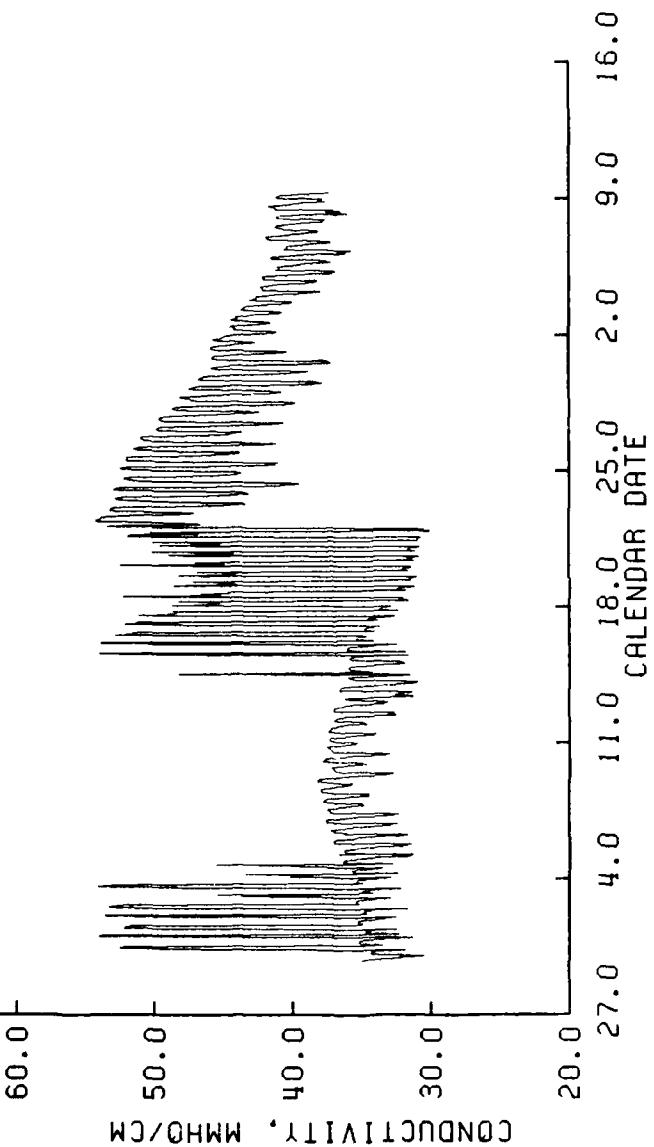
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ENDECO 174, STATION PIYAB  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



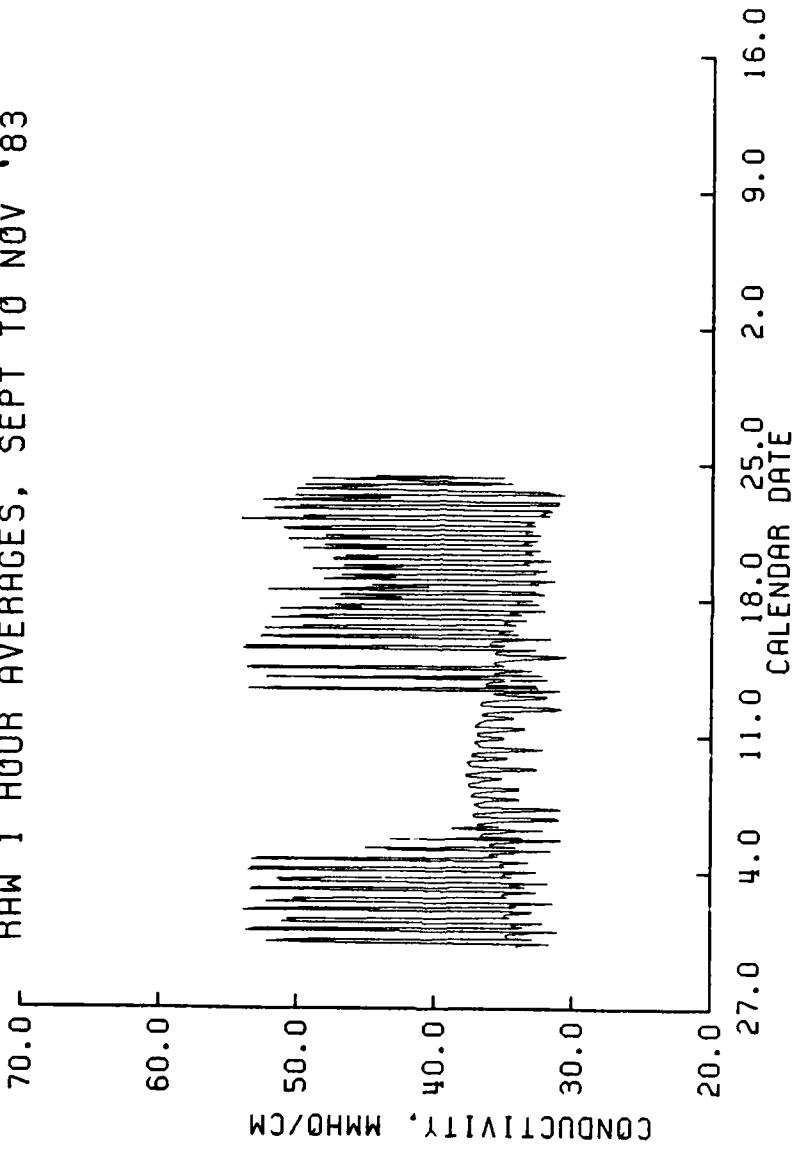
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ENDECO 174, STATION PI4AT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



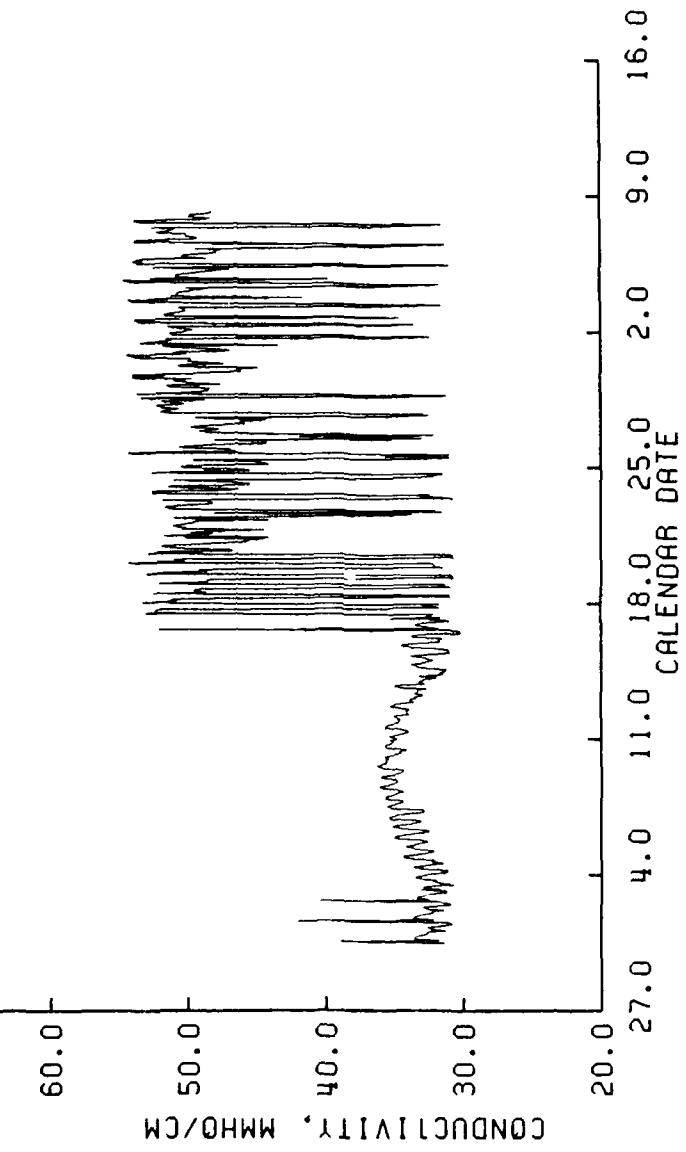
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ENDECO 174, STATION P14BB  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



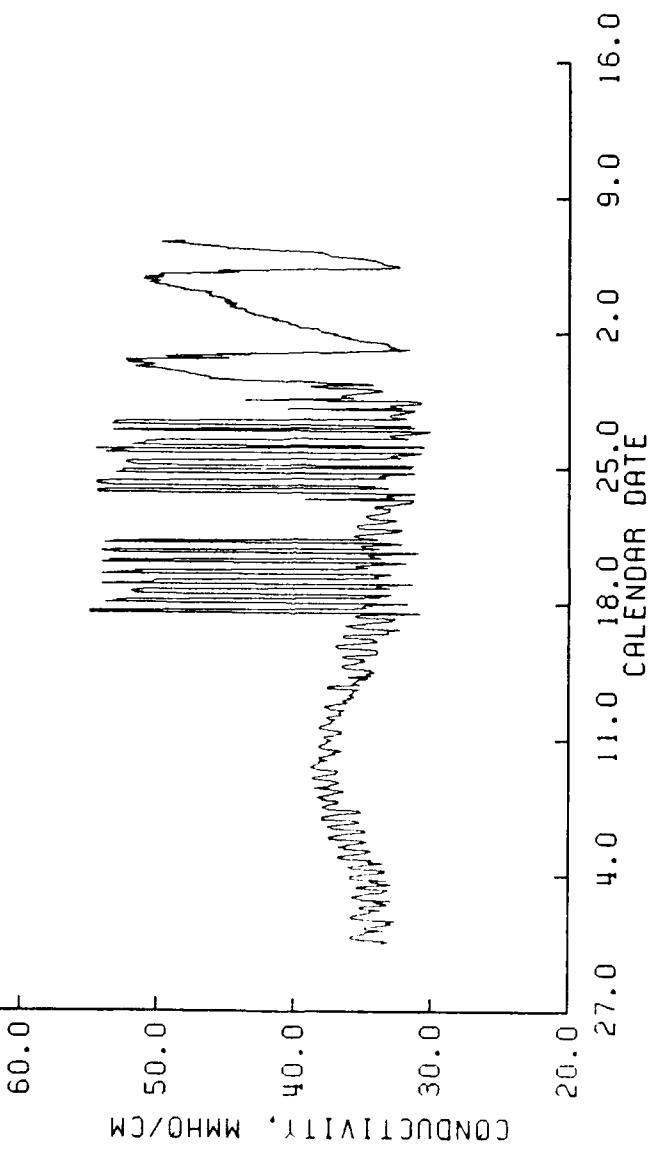
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PI4BT  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



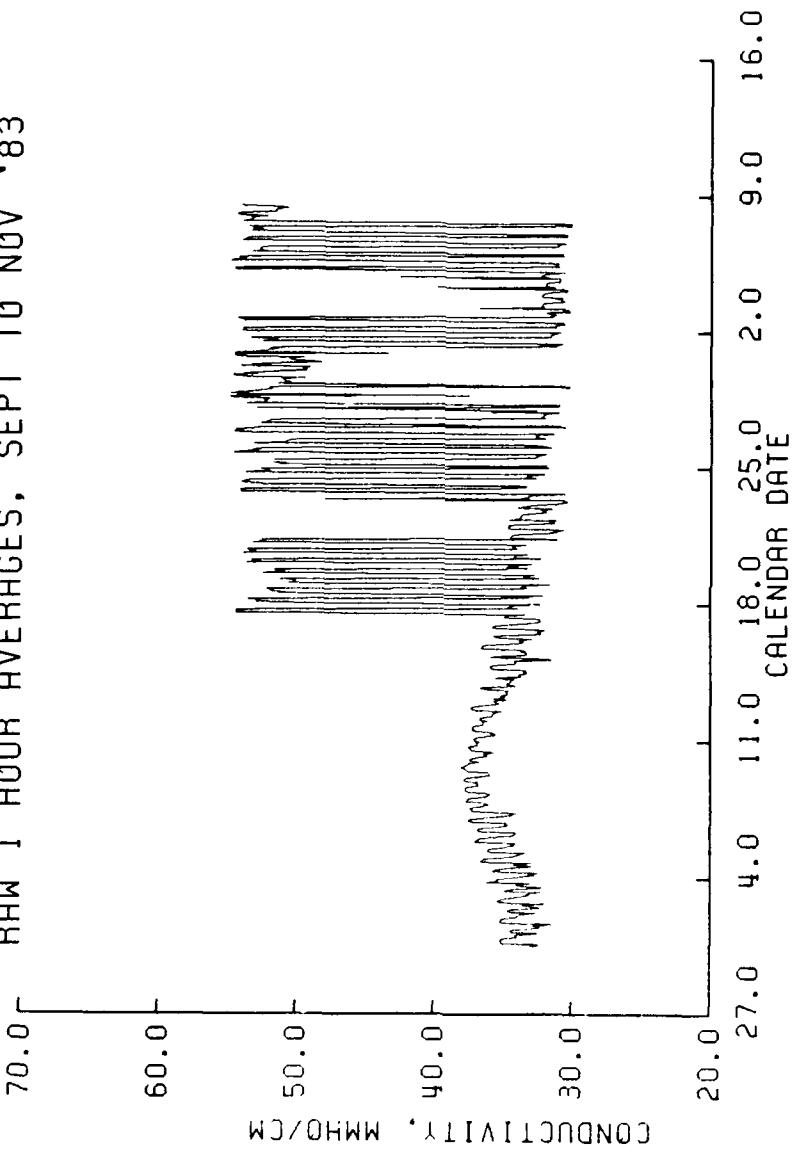
PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION PISA  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P15B  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



PONCE DE LEON INLET PROJECT  
ENDECO 174, STATION P15C  
RAW 1 HOUR AVERAGES, SEPT TO NOV '83



END

DATE

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